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14. ABSTRACT
This TOP provides guidance for planning engineering tests of recoilless rifle ammunition. It outlines test phases to be included and points out important features to be considered for each phase. The procedures apply to other types of proving ground tests of recoilless rifle ammunition as well as engineering tests.

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US ARMY DEVELOPMENTAL TEST COMMAND
TEST OPERATIONS PROCEDURE

*Test Operations Procedure (TOP) 4-2-013 22 September 2009
DTIC AD No.:

RECOILLESS RIFLE AMMUNITION

*This TOP supersedes TOP 4-2-013, 01 July 1971.

1. SCOPE.

This TOP contains a compilation of procedures for testing ammunition used by recoilless rifles. The test procedures apply to ammunition only; see TOP 3-2-066[1*] for test procedures for recoilless rifles. Numerous other documents relevant to testing Recoilless Rifles systems are referenced throughout the document. Unless specified otherwise the most recent version of the referenced document at the time of testing will be utilized.

a. Ammunition fired from recoilless rifle systems range from 66mm to 105mm. Projectiles are typically fin or spin stabilized launched from a single/short duration propulsion event from a pressure vessel or cannon barrel. Projectiles typically do not have any sustained propulsion or flight control. Projectile acceleration force ranges from 5,000 g's to 17,000 g's as opposed to missiles and rockets that experience far less acceleration force. Service ammunition includes all ammunition likely to be used in combat; included are high explosive (HE), high explosive anti tank (HEAT), high explosive dual purpose (HEDP), tandem-warheads, illumination, flechettes, enhanced blast and smoke, etc.

b. Many of the test procedures of this TOP are based on existing procedures detailed in such documents as International Test Operating Procedures (ITOPs), NATO Standardization Agreements (STANAGs), Military Standards etc. These documents must be thoroughly reviewed to properly conduct their subject tests. Many of the referenced documents assume test items much larger than typical recoilless rifle ammunition; this TOP gives information for tailoring such procedures to be more suitable for recoilless rifle munitions.

c. The test procedures are meant to help standardize testing and to aid the development of Detailed Test Plans (DTPs), Test and Evaluation Master Plans (TEMPs), and similar planning documents. This TOP does not constitute a requirement to do any of the specific tests nor does it serve to set performance or safety criteria for Army materiel. Actual requirements and criteria must come from requirements documents, contractual obligations, Army Regulations, etc.

2. FACILITIES AND INSTRUMENTATION.

The lists below show specialized items that are used in the test procedures. Additional information is contained in the individual test procedures since requirements for accuracy and precision of a given measurement may vary among the procedures. Standard equipment common to most technical organizations is not listed; however, the test officer must assure that the specific requirements of each procedure are met by whatever equipment or instrumentation is used.

[*] Superscript numbers correspond to those in Appendix A, References.

2.1 Facilities.

ITEM	REQUIREMENT
Firing Ranges	Ranges must safely accommodate firing to the required distances; range safety fans must consider the possibility of catastrophic failure of weapons and ammunition.
Test stands	Must safely restrain the weapon, allow remote firing, and assure reproducible results.
Ground mounts (Ballistic Pendulum, accuracy, Blast Overpressure, etc.)	Specific to the test support weapon.
Support ammunition	Similarity to the test ammunition to permit checkout of test setups, instrumentation, etc.
Reference ammunition	Assessed for chamber pressure and velocity.
Targets	Physical or electronic with the capability of recording the X and Y coordinates of each projectile passing through the plane of the target; specific accuracy requirements will vary among the various tests, but in all cases the accuracy and precision must be sufficient to address the criteria for the particular test being done. Other targets, such as armor plate, fuze functioning media, etc. as required.
Pressure barrels	Barrels chambered for the test cartridge and ported for electronic or crusher type pressure gages.
Climatic chambers	Meet the requirements of MIL-STD-810G[2]. Chambers must be capable of providing and maintaining temperatures of +71 °C to -54 °C.
Salt Fog Chamber	Chamber shall be capable of producing salt fog of up to 3ml of solution per hour per 80 sq cm at temperatures up to 35 °C.
Sand/dust chamber	To dispense mixture at rate of 100 ± 25 g/min/m^2
Dust chamber	To dispense mixture at a rate of 50 ± 10 g/min/m^2, temperature control to ± 2 °C.
Electromagnetic Test Facility	16 Hz through 40 GHz, susceptibility levels up to 200 V/m

2.2 Instrumentation.

ITEM	MAXIMUM PERMISSIBLE ERROR OF MEASUREMENT*
Brookfield viscometer	±0.5% full-scale reading
Cyclic rate recorder	± 1% at rates up to 6000 spm and burst lengths of 100 rds.
Stargage and borescope	±0.025 mm
Thermograph/thermocouples	±0.6 °C (1 °F)
Velocimeter	0.1% or 0.5 m/s (whichever is highest) for bursts to 6000 spm.
Impulse noise measuring system	Peak pressure to ±1 db A-duration, B-duration, to ±10%
Mud bath	Viscosity of 4600 centipoises
Salt water solution	5% sodium chloride and 95% water
Fuze Chronograph	Self destruct time, ± 0.01 second

*Values can be assumed to represent ±2 standard deviations; thus, the stated tolerances should not be exceeded in more than 1 measurement of 20.

3. REQUIRED TEST CONDITIONS.

3.1 Planning.

a. Review the Safety Assessment Report and all instructional material issued with the test item by the developer and manufacturer, as well as reports of previous tests conducted on the same model or closely related item. Review the Safety Release if one exists.

b. Review the test item's capability documents (if any) such as the Initial Capability Document (ICD), Capability Development Document (CDD), or Capabilities Production Document (CPD). For evaluated programs, the ATEC coordinated and approved System Evaluation Plan (SEP) is the governing document. The SEP will document the methodology and data requirements and any unique test and evaluation methodologies beyond those stipulated in this TOP. For non-acquisition projects, the customers test requirements will be followed to the extent possible, based on information in the Request for Test Services (RFTS) and direct communication with the customer. See DTC Pam 73-1[3], Chapter 4, for additional information about test planning.

c. Assemble information on the physical characteristics of the test item, its method of operation, maintenance requirements, and expected modes and areas of deployment. Review the information to determine any effect on testing procedures such as environmental impact, temperature requirements, handling precautions, etc.

d. Based on the above information, plan a comprehensive testing program to verify that the test item satisfies minimum design and construction requirements for safe field deployment and can also provide performance data that can satisfy user requirements. Tests appropriate for forming a test program are described in paragraph 4. For some test programs, these procedures will need to be expanded or special test considerations will be required, while in many other cases, not all procedures contained in this TOP will be applicable.

3.2 Sample Size.

The number of test samples needed depends heavily on the type of test and what the test results are expected to accomplish or support. For example, a Technical Feasibility Test may only require a small sample size whereas an Engineering Development Test designed to support a Milestone C decision would require a much larger sample size (see DTC Pamphlet 73-1 for definitions of test types and milestones). Although test economy must also be considered, the sample size must be sufficient to provide reasonable assurance that comparison of test results against requirements will be meaningful. ITOP 3-1-005[4], Statistics for Test Assessment, provides guidance in selecting samples for desired levels of confidence in test results. Documents such as the SEP or CDD should be reviewed for required sample sizes or for confidence levels from which sample sizes can be derived. Consult with a statistician or independent evaluator if needed to resolve sample sizes against test criteria. Consideration must be given to the possibility of combining data from separate test procedures to effectively increase sample sizes and confidence in results. All sample size decisions should be coordinated with the ATEC System Team Lead or assigned independent evaluation agency before making a final determination.

Whenever a certain minimum sample size is specified in this TOP, the number is considered adequate to detect fundamental and consistent ammunition characteristics in a particular environment. The sample size of ammunition for safety testing is based on reasonable and successful prior development testing and observations. When there is minimal testing conducted during early development and the design has not been adequately proven, the safety testing quantities need to be increased. A larger sample size must be used when marginal performance or randomly encountered problems are expected and are to be measured with some degree of confidence.

3.3 Test Sequence.

Conduct safety tests and high-risk tests first to provide an early indication of suitability. This TOP does not include a recommended sequence for the complete series of subtests due to the many variations of ammunition and weapon designs and due to facility considerations such as the scheduling of ranges and laboratory support. Ammunition should not be used for multiple tests as conditioning in one environment might lead to a failure in another.

3.4 Test Conduct.

a. Support weapons. The safety and suitability of recoilless rifle ammunition is interrelated with the weapons with which it is used. Care must be taken during testing to assure that the distinction is made between inherent ammunition functioning and weapon induced problems. Weapons will be maintained in accordance with technical manuals, if available. Weapons will always be cleaned, inspected, and lubricated (CIL) at the end of each test procedure and before the start of another procedure (the CIL at the end of a test procedure may serve as the CIL for the start of a subsequent test procedure based on the judgment of the test officer). At a minimum, the CIL will be conducted at the operator level (often referred to as “field strip and clean”). More detailed maintenance will be done as needed. Weapon lubricants, gas port settings, etc. may be specific to test conditions such as extreme temperatures and must be applied in accordance with technical manuals or requirement documentation. All maintenance actions will be recorded. Weapon maintenance procedures should be coordinated with the ATEC System Team lead or assigned independent evaluation agency, the Program Manager and weapon manufacturer prior to the initiation of testing.

b. Firing tests. Test ammunition must be fired to determine its performance in its intended weapons. Review all instructional material issued by the manufacturer, contractor, or government, as well as reports of previous similar tests conducted on the same type or test item; familiarize all test personnel with the contents of such documents. Keep these documents readily available for reference. Request that New Equipment Training is provided for personnel that will be conducting the testing.

c. Support ammunition. The limited amount of test ammunition should be preserved for actual testing. Support ammunition similar to the test ammunition should be provided if at all possible. The support ammunition is used to check out test set ups and instrumentation function, and to perform trial runs prior to the use of the test ammunition. Support ammunition is also used to verify proper function of the support weapons. Some support ammunition may be used for direct comparison with the test ammunition in comparative tests such as toxic fumes, muzzle flash, tracer intensity, etc. The support ammunition used must be fully identified; record the full nomenclature, Department of Defense Identification Code (DODIC), condition code (CC) and lot number.

d. Ammunition handling. The test ammunition should be kept in its original shipping and storage containers until immediately before use. Make a general visual examination of the ammunition after it is removed from its packaging for a test; record any discrepancies such as shipping damage, evidence of improper storage, etc. Use the guidelines from paragraph 4.1.1, Initial Inspection, to inspect the ammunition. Save some of the original shipping containers and packing materials; they are often needed to repack ammunition after various rough handling and environmental tests.

4. TEST PROCEDURES.

4.1 Basic Tests.

Basic tests are common across the different types of recoilless rifle ammunition. These tests should be done to assure basic ammunition safety and functionality before extensive firings are done. The data for some of these tests may be available from the manufacturer or from other government agencies; in such a case it may not be necessary to repeat the test.

4.1.1 Initial Inspection.

a. Background. Cartridges received for test are examined for damage and defects. This examination is primarily visual; dimensional checks, such as for overall length, weight, etc.

CAUTION: The following procedures require extensive handling of unpackaged ammunition. The inspections must be carried out in an approved facility by personnel certified in ammunition handling.

b. Method.

(1) Shipping containers and packing material. Inspect the exterior of all packages for physical damage, water stains, or any other evidence of improper storage or handling. Record how the packages are marked. Note how the cartridges are packed, recording the type of container, overwrap (if any), and number of cartridges per container. Open one container and any interior containers to expose the test ammunition. Record the type and condition of any interior packing material, padding, or spacers. Inspect the interior of the container for foreign material, loose propellant, evidence of moisture, and general cleanliness. Record the markings of any interior containers such as bandoliers, cardboard boxes, loaded magazines, etc., and note their condition.

(2) Cartridges. Thoroughly inspect each cartridge in the opened package. Use the Military Specification for the test item as a guide for determining and reporting any defects found in the inspection. The list below indicates many of the things to look for during the inspection.

(a) Manufacturer and manufacturer’s lot number.

(b) Markings on the cartridge.

(c) Cartridge case material.

(d) Type of projectile, i.e. HE, HEAT, HEDP, ILLUM, etc.

(e) Exterior condition – dirt, corrosion, staining, etc.

(f) Waterproofing at the primer pocket and case mouth.

(g) Dents, splits, scratches, etc. in the case or projectile.

(h) Identification markings.

(i) Primer condition, i.e., cocked, loose dented, etc.

(j) Crimp between the case and projectile.

c. Data Required.

(1) Photographs of the test item and packaging.

(2) Results of visual inspections.

(3) Pallet Configuration

4.1.2 Physical Measurements.

a. Background. It is not feasible to check all possible physical measurements of a complete round of ammunition. Judgment must be used to determine what measurements are necessary; measurements critical for safety must always be checked.

b. Method. The dimensions and weights shown below should be recorded from a minimum of ten rounds. Use TOP 4-2-500[5] as a guide for measurements.

(1) Weight of complete cartridge.

(2) Overall length of cartridge.

(3) Projectile diameter at bourrelet and/or rotating band.

(4) Center of Gravity.

c. Data Required. Dimensions and weights as recorded.

4.1.3 Human Factors.

a. Background. Recoilless rifle ammunition is useful only to the degree that Soldiers can use it effectively and safely. Detailed instructions for Human Factors tests are given in TOP 1-2-610, Human Factors Engineering, Part I[6], Test Procedures, and Part II[7], HEDGE, Human Factors Engineering Data Guide for Evaluation.

Human factors tests can be done informally by accumulating data throughout all testing, or they can be done formally by a test dedicated purely to human factors.

b. Test Method.

(1) Informal Human Factors Evaluation.

(a) Throughout all test operations, observe and record data related to the effectiveness with which the test ammunition is deployed, used, and maintained by representative users and the degree to which it is compatible with the capabilities and limitations of individual operators. Typical areas of interest are unpacking the ammunition, handling of packed and unpacked ammunition, clarity of identification markings, ease of loading and firing in various positions, and signature effects such as smoke, muzzle flash, noise and recoil. Use the task checklists for individual weapons and for crew served weapons contained in TOP 1-2-610, Part II, for guidance.

(b) Review the Operators Manual (if provided) for accuracy and ease of understanding.

(c) Take advantage of opportunities to "piggy back" human factors testing. For example, provide military issue cold weather gloves to weapon operators during extreme cold functioning tests and observe for the ease of unpacking the ammunition and loading a weapon.

(d) Use Soldier-Operator/-Maintainer Test and Evaluation (SOMTE) soldiers wherever possible to conduct tests; record their observations and remarks in accordance with TOP 1-2-610.

(2) Dedicated Human Factors test.

(a) Review requirements documents and the TEMP, SEP, etc., for human factors requirements.

(b) Consult with a human factors engineering specialist to plan the test. Evaluate the adequacy of human factors engineering of the test system using appropriate data-collection aids (task lists, performance checklists, error reports, interview forms, rating scales, etc.) in accordance with TOP 1-2-610.

c. Data Required.

(1) Observations of human factors throughout testing.

(2) Information from questionnaires and interviews.

(3) Instrumentation and facilities used.

(4) Physical measurements such as test item weight and dimensions, force required to charge weapons, etc.

(5) Anthromorphic data.

(6) Participant skills, MOS, etc.

(7) Details of test procedures.

4.2 Interior Ballistics.

These tests relate to the ammunition's performance from the time that the primer is ignited until the time the projectile leaves the barrel.

4.2.1 Pressure and Velocity.

a. Background.

While pressures and velocities can be determined by separate tests, they should be recorded simultaneously if at all possible. Pressures will be measured at locations in the barrel as required by cartridge specifications; these locations can be at the mid-point of the cartridge case, at the case mouth, or at the location of a weapon's gas port. Velocities are recorded as corrected to muzzle, or to a specific instrumentation point as noted in the cartridge specifications.

b. Test Method.

(1) Barrel design. Barrels for this test must be ported (drilled) at the pressure locations. The barrel breeches must be instrumented to determine the moment of primer initiation. The barrels used for this test are typically Mann Barrels.

(2) Most recoilless rifle ammunition specifications require the use of piezoelectric transducers for pressure measurements. There are a variety of transducers and procedures for their use; the ammunition specifications must be consulted to determine the specific transducer and procedure to use. General guidance and procedures for the use of piezoelectric transducers for pressure testing are given in ITOP 3-2-810[8], Electrical Measurement of Weapon Chamber Pressure. Assure that the transducers are properly calibrated before use. Install and maintain the transducers in strict accordance with the manufacturer's instructions for that specific transducer model.

Cartridge cases must be drilled at the location corresponding to the location of the port drilled through the barrel. Exercise care to assure that the drill does not remove any propellant from the cartridge case. Drilling must be done in a protective enclosure as there is a chance of propellant ignition; this is particularly true when drilling steel cartridge cases. Seal the drilled hole as noted in cartridge specifications, if no information is available use a single layer of cellophane tape.

(3) Reference cartridges must be fired and the correction factors computed for each days firing. Fire a minimum of three support cartridges to condition the barrel and to assure that the instrumentation is functioning correctly. Temperature condition 20 reference cartridges to 21 ± 2 °C for a minimum of two hours. Fire the reference cartridges at a cadence of about one shot per minute. Calculate the mean pressure and mean velocity produced by the reference cartridges and compare them with the assessed values for the reference cartridges. If the assessed value is

higher than that actually obtained, the difference shall be added to the values of subsequent test rounds. If the assessed value is lower, the difference shall be subtracted from the values for test rounds. These correction factors are applied regardless of the temperature at which test rounds are fired. There is a limit to how large the correction is allowed to be before the barrel is disqualified; these limits must be obtained from the cartridge specifications. There is no rule for barrel rejection if there is no cartridge specification; a similar cartridge's specification may give some guidelines, or if there is no guidance whatsoever, consider a barrel to be suspect if the pressure or velocity vary more than 5% from the assessed value.

The propellant in each cartridge case must be uniformly positioned from shot to shot. Remove the cartridge from the temperature facility and hold it vertically, projectile upward. Slowly rotate the cartridge 360 degrees in a vertical plane, stopping momentarily with the bullet downward, and then continuing until the cartridge is projectile end up again. Lower the projectile end until it is slightly above horizontal and guides it into the barrel chamber. (The object is to have the propellant seated in the primer end of the case with any airspace at the projectile end of the case).

Take less than 30 seconds to remove the cartridge from the temperature facility, perform the rotation, and load and fire the weapon. Fire at a cadence of about one shot per minute. Cool the barrel and breech between cartridge samples.

(4) Test cartridges are fired using the same procedures as for the reference cartridges. Temperature condition the test cartridges for a minimum of two hours at 21 ± 2 °C before firing. Test cartridges should also be fired at extreme temperatures to assure safety. If no other guidance is given, use +71 ± 2 °C and -54 ± 2 °C for the extreme temperatures. Use a sample size of 45 if no other guidance is available.

(5) Conformal Pressure Gages. Conformal gages are a specialized type of piezoelectric transducer. These gages are generally only used for acceptance procedures in manufacturing plants. The gage is mounted in the barrel such that its sensing tip is in direct contact with the cartridge case (which is not drilled). The contact surface of the gage is curved to conform to the cartridge case. When fired, the cartridge case expands from the internal pressure thus transmitting the force to the sensing element of the conformal gage. The output of the gage is then translated to the pressure in the chamber.

(6) Projectile velocity may be recorded with any suitable instrumentation. The same instrument should be used throughout the test. Velocities should be reported as corrected to muzzle or to an instrumentation point as required by the cartridge specification (reference ammunition will have a specified point at which the velocity must be recorded).

c. Data Required.

(1) Complete description of test set up and instrumentation.

(2) Calibration history of piezoelectric transducers.

(3) Identification of reference ammunition and its assessed values.

(4) Pressures and velocities as recorded.

(5) Calculated correction factors.

(6) Corrected values for pressures and velocities.

(7) Ammunition Temperature.

4.3 Exterior Ballistics.

These tests relate to the flight of the projectile from the time it exits the barrel until the end of its trajectory.

4.3.1 Accuracy and Dispersion.

a. Background.

(1) This test determines the inherent accuracy and dispersion characteristics of the test ammunition.

(2) Accuracy is a measure of the ability of weapon-ammunition system to center projectile impacts on the point of aim. Dispersion is the extent to which projectile impacts spread about the center of impact because of shot-to-shot variations. Methods of calculating measurements of accuracy and dispersion are given in ITOP 4-2-829[9].

(3) Results of the accuracy and dispersion test are often used as a "baseline" for evaluation of subsequent test results, such as for ammunition that has been subjected to rough handling. Ideally, accuracy and dispersion data will be generated by each of three separate procedures. a. Firing the ammunition from a special test barrel (often referred to as a "Mann barrel"); b. Firings from the weapon/ammunition combination from a test stand; c. Manned firing of the weapon/ammunition combination (man-in-the-loop). Conducting all three procedures will allow comparison of data across conditions and will greatly aid the development of an error budget.

b. Method.

(1) Meteorological conditions: Wind conditions greatly affect the flight of the bullet and must be kept at a minimum to assure quality results. A steady, unvarying wind has a moderate effect on dispersion but can seriously affect accuracy measurements. Gusty winds adversely affect both accuracy and dispersion measurements and should be avoided. Firing from the wind free environment of an enclosed range is preferred. For open ranges the recommended maximum wind conditions are: transverse wind no greater than 8 km/hr (5 mph) or varying by more than 4 km/hr (2.5 mph), wind parallel to the line of fire no greater than 16 km/hr (10 mph) or varying by more than 8 km/hr (5 mph). These are the maximum wind recommendations and are not necessarily acceptable for all recoilless rifle projectiles at all ranges. Records of previous tests of the same or closely related ammunition should be consulted before establishing the maximum permitted wind velocities for the test.

Firings should be done with the weapon and ammunition at standard ambient conditions (25±10 °C (77 ± 18 °F) and 20 to 80% relative humidity. If wind and temperature conditions can not be met due to program requirements, seasonal meteorological conditions etc., consult with the program evaluator, customer, and test manager to obtain an agreement of acceptable conditions.

(2) Targets: Steel targets that do not physically interfere with the bullet trajectory are preferred. Steel targets also expedite the test by allowing multiple shots at the same target, since recoilless projectiles will destroy plywood targets on impact. Care must be taken to establish a reproducible aim point. Targets, such as paper or cloth may also be used; these targets will not allow the projectile to function and will leave unexploded ordnance on the range. Targets are positioned perpendicular to the line of fire.

Position targets at the ranges indicated by the requirement documents or test plan. Mount the test barrel in a machine rest, verify that all fittings are in place and are properly tightened. Sight alignment is checked before each shot is fired. Use a boresight (optical or laser) as necessary to check alignment to the target aiming point if the barrel is not equipped with suitable sights. Assure that the barrel does not become overheated; it should not be too hot to hold in a bare hand. Check the barrel mount after each target.

Repeat the firing procedure if additional targets are needed at different ranges or for different ammunition temperatures. If temperature conditioned ammunition is used, it should be fired within 5 minutes of being removed from its temperature controlled environment.

Zero each weapon in accordance with the weapon or sight manual; zero hand and shoulder weapons for 100 m if manuals are not available. Fire any additional rounds needed to assure that the weapon is sighted on target. Place the weapon in a mount that will hold it securely and maintain its point of aim. Use the weapon sights to aim the weapon at the target aim point. For weapons capable of being fired single shot, fire at target while checking sight alignment between each shot. Check the weapon mount after each target.

Repeat the firing procedure if additional targets are need at different ranges or for different ammunition temperatures. If temperature conditioned ammunition is used, it should be fired within five minutes of being removed from its temperature controlled environment.

c. Data Required. Measure and record the following:

(1) Identification of barrels and weapons.

(2) Results of weapon inspection and bore measurements, etc.

(3) Procedures used to mount and fire weapons.

(4) Target ranges and nature of target.

(5) Photographs of test mounts and bench rest firing facility.

(6) X and Y coordinate of each impact relative to the aim point.

(7) Meteorological conditions including wind, temperature, humidity, and air density.

(8) Target data reduced in accordance with ITOP 4-2-829.

(9) Ammunition Temperature.

4.3.2 Range Tables.

a. Background. The purpose of this test is to gather data that will allow the computation of the external ballistics for specific ammunition/weapon combinations. The computations are used to construct firing tables, produce computer programs for weapon sights, establish firing range safety dimensions, etc. Final data analysis and publication of firing tables is the responsibility of the Firing Tables and Ballistics Division of the U.S. Army Armament Research, Development and Engineering Center; details of the test procedure and data requirements must be coordinated with this group prior to testing.

b. Test Method.

(1) The test method is detailed in ITOP 3-2-601[10], Firing Tables and Ballistic Match Tests. The information presented below is intended to supplement the ITOP and to provide procedures specifically for Recoilless rifle ammunition.

(2) Ammunition selection. Ammunition selected for this test should be representative of production. All components must be present, including projectile paint and markings, fuzes, any tool marks, etc.

(a) Weights of each individual projectile should be obtained from the loading plant or local disassembly and reassembly. For small calibers, it may be necessary to weigh a sample of projectiles and use the average weight for the ballistic computations.

(b) Precise physical measurements of the projectile are required. The required measurements are listed in paragraph 4.3.2.c, Data Required. Detailed procedures for many of the specialized measurements, such as moments of inertia and unbalance, are given in ITOP 4-2-801[11], Projectile Unbalance.

(3) Weapon selection. Support weapons must be serviceable in all respects. Examine the weapon bore with a borescope and record its condition; measure the bore at intervals of 25mm (1 inch) for its complete length. The weapon should be equipped the same as it will be used in service; flash hiders, muzzle brakes, noise suppressors, etc. must be installed. If the weapon features interchangeable components such as different barrel lengths or muzzle attachments, the test should be repeated with each configuration. This test is typically performed with production representative weapon systems.

(4) Meteorological requirements. Meteorological data is an absolute requirement for exterior ballistics computations. Data will be recorded both at the firing position and aloft to the expected maximum ordinate. Record wind speed and direction, air pressure, temperature, and humidity. As a minimum, the meteorological data will be recorded at the start of the test firings and just after the last round is fired. Wind and temperature at the firing site should be recorded for each individual round. Additional low level wind data may be required between the weapon and the target area. For maximum ordinates below 1500m (5000 ft), observe surface wind limitations of an average of 5 m/s (11 mph) with gusts not exceeding 2.5 m/s (6 mph); see ITOP 3-2-601 for recommended limits for ordinates above 1500m.

(5) Instrumentation and facility selection. The basic ballistic data of velocity versus time is recorded by use of Doppler radar. The radar must be capable of recording data to the maximum expected range of the projectile. Start time (projectile exit from the muzzle) must be recorded; this is done by use of a muzzle sensor such as an infrared detector. The weapon is mounted such that its location and elevation relative to the radar does not change from shot to shot. Position the weapon mount forward of the radar so as to minimize the intercept angle of the radar relative to the line of fire; the intercept angle should be less than three degrees.

(6) Firing procedure. Use the following general procedure if no other guidance is available:

(a) Record the relative positions of the weapon muzzle and the radar (this requires precise geodetic measurements).

(b) Fire three non-test rounds to condition the barrel.

(c) Precisely record the muzzle elevation using a gunner’s quadrant or geodetic measurements.

(d) Maintain the ammunition and weapon at the same ambient temperature.

(e) Load the weapon one round at a time using normal operator procedures.

(f) Fire at an elevation of six degrees for shoulder and hand fired weapons.

(g) Fire at an elevation of 15 degrees for high angle of fire weapons such as grenade machineguns.

(h) Verify weapon elevation between each shot.

(i) Fire a sample of ten rounds.

(j) Record velocity versus time from projectile exit to ground impact.

(7) Use of targets. Some exterior ballistics tests require the use of physical or electronic targets; this allows the collection of dispersion data along with the data from the radar. The target aim point must be surveyed to record its location relative to the weapon and radar. Align the weapon muzzle with the target aim point using a boresight and record the quadrant elevation. Apply the required superelevation to obtain the desired muzzle elevation above the aim point. Fire using the procedures above. Record each round's target data so that it can be correlated with the radar data for that round. If a physical target is used, inspect the projectile imprint for evidence of yaw, projectile deformation, etc.

(8) Ballistic match. The ballistic match test is conducted to determine if two different projectiles have external ballistics similar enough that they can use the same firing tables, sight settings, range safety fans, etc. The test is done using the procedures above except that the two types of ammunition are fired alternately. The rounds should be fired as quickly as practical to reduce the influence of variables such as wind.

(9) Maximum range. The maximum range attainable by a projectile is needed to establish range safety fans. Use the above firing procedures except that firing is done at elevations expected to give maximum projectile range to ground impact. Fire ammunition samples at 30, 35, and 40 degrees elevation (five round samples are recommended). It is not usually necessary to fire at intermediate elevations as the ballistic data can be reduced and interpolated to determine the precise maximum range and the elevation required to attain that range. Meteorological data, such as winds aloft, are required up to the expected maximum ordinate.

c. Data Required.

(1) Record the following projectile characteristics;

(a) Diameter, including bourrelet and rotating band if appropriate.

(b) Projectile weight.

(c) Projectile profile including length of ogive, length of straight section, and length and angle of any boattail.

(d) Center of gravity.

(e) Measurements of imbalance, if appropriate.

(f) Moments of inertia.

(g) Fin shape and angle, if appropriate.

(h) Ammunition Temperature

(2) Record the following support weapon characteristics:

(a) Make, model, and serial number.

(b) Bore measurements.

(c) Muzzle attachments if appropriate.

(d) Loading and firing procedure used.

(3) Record meteorological conditions as follows:

(a) Wind speed and direction.

(b) Temperature.

(c) Air pressure.

(d) Humidity.

(e) Location of measurements relative to the weapon.

(4) Record instrumentation and test facility information as follows:

(a) Identify the specific radar used to collect the data.

(b) Type and identification of muzzle sensor.

(c) Geometric location of the weapon muzzle relative to the radar.

(d) Weapon azimuth and elevation.

(e) Target description and location, if any.

(5) Record the following ballistic data:

(a) Velocity versus time as recorded by the Doppler radar.

(b) Target impact coordinates, if appropriate.

(c) Observation of any abnormalities in target impact markings.

4.3.3 Strength of Design.

a. Background. Strength of design tests are conducted with inert loaded projectiles and fuzes to ensure that it is safe to proceed into the safety test using live loaded projectiles. Strength of design testing is conducted at pressures 5% above the peak safety test pressures established for the testing of live loaded projectiles. At least twenty one projectiles are required. At least 20 are fired for recovery, and one is checked for hardness, sectioned, and examined to verify that physical property requirements are met. Sectioning and examination can be omitted if the developer provides the required data. (Not required for propelling charge safety tests).

b. Test Method.

(1) Take prefire dimensional measurements of the projectiles. Measurements shall include shell body length, bourrelet diameter, and rear ogive diameter. Compare with drawing requirements. If satisfactory proceed with the test.

(2) Scribe index marks across all joints, as applicable.

(3) Fire one-half of the cartridges conditioned to 63 °C with charge designed to produce 105% of peak testing pressure at 63 °C for recovery. Fire the remaining cartridges conditioned at -46 °C with the propelling charge designed to produce 105% of peak test pressure at -46 °C for recovery.

(4) Recover the projectiles, guidance in TOP 4-2-809[12]. If fewer than seven of each group is recovered, additional projectiles may be measured and fired.

(5) If the items under test are cargo carrying projectiles, a portion of the projectiles should be fired in the ejection mode and the cargo and carrier recovered and examined.

(6) During firing, photograph the initial flight of each projectile, and measure chamber pressure and muzzle velocity for all rounds.

(7) Examine recovered projectile for the loss or breakup of metal parts or components and radiograph as required and re-measure recovered projectiles.

(8) The test is done by firing through vertical witness screens to detect parts or fragments that may separate from the projectile while it is in bore or in the early part of its flight.

(9) Weapon selection. Support weapons must be serviceable in all respects. Examine the weapon bore with a borescope and record its condition; measure the bore at intervals of 25mm (1 inch) for its complete length. The weapon should be equipped the same as it will be used in service; flash hiders, muzzle brakes, noise suppressors, etc. must be installed.

(10) Witness screens. Screens may be constructed of any convenient material; fiberboard and light plywood are commonly used. The surface of the screens is smooth, clean, and light colored (white paint may be required) to facilitate inspection. A hole is cut in the center of each screen so that the projectiles may pass through unimpeded. One screen should be placed as close to the muzzle as feasible, usually at 5 meters for small calibers (less than 20mm) and 10 meters for larger calibers. A screen should be erected at the maximum practicable distance, usually at 50 meters. At least two screens should be placed at intermediate distances.

c. Sample size. The number of test samples needed depends heavily on the type of test and what the test results are expected to accomplish or support. For example, a Technical Feasibility Test may only require a small sample size whereas an Engineering Development Test designed to support a Milestone C decision would require a much larger sample size. Consideration must be given to the possibility of combining the Strength of Design test procedures with other tests to effectively increase sample sizes and confidence in results. The minimum recommended sample size is 459 rounds which, if there are no failures, will indicate 99% reliability at 99% confidence.

d. Ammunition temperature. If no other guidance is available, divide the ammunition into three equal groups. Fire one group at range ambient (or conditioned to 21 ± 2 °C (70 ±4 °F), fire the second conditioned to -46 °C (-50 °F), and the third conditioned to 52 °C (125 °F).

(1) Thoroughly inspect the witness screens during weapon cooling periods, between ammunition temperature change, and at any time there is a change in firing conditions. Look for imbedded debris, perforations, smudges, and any other markings on the screen. Recover any embedded debris. Measure and photograph perforations and marks. If necessary take samples of smudges or particles and have them analyzed for chemical composition.

e. Data Required.

(1) Identification of ammunition and support weapon.

(2) Meteorological conditions of wind and air temperature.

(3) Ammunition temperature.

(4) Description of witness screen material and size.

(5) Location of witness screens.

(6) Location of marks relative to the line of fire and weapon position.

(7) Description and photographs of any recovered debris.

(8) Date and time of firing.

(9) Projectile weight.

(10) Propelling charge weight.

(11) Weapon elevation.

(12) Muzzle velocity.

(13) Weapon chamber pressure using crusher gauges and/or electrical transducers.

(14) Weapon inspection records.

(15) Projectile physical measurements before firing and after recovery.

(16) Recovery method.

(17) X-rays of recovered projectiles, as required.

4.3.4 Debris Field.

a. Background. This test is done to determine the spatial distribution of ammunition debris projected from the weapon. Sabot debris is the most common, but other items such as flechettes and submunition carriers must also be considered. The debris distribution has safety implications, such as when firing over the heads of friendly troops, and is also needed for the determination of range safety fans and training scenarios. This test is often combined with the Weapon Compatibility Test, the Strength of Design Test, or other firings.

b. Test Method.

(1) The test is done by firing through vertical witness screens to determine the distribution of the debris. It may be necessary to use tracking radar if debris is projected to a range that makes witness screens impractical.

(2) Weapon selection. Support weapons must be serviceable in all respects. The weapon should be equipped the same as it will be used in service; flash hiders, muzzle brakes, etc. must be installed.

(3) Witness screens. Screens may be constructed of any convenient material; fiberboard and light plywood are commonly used. The surface of the screens is smooth, clean, and light colored (white paint may be required) to facilitate inspection. The screens should be constructed so as to be easily portable since they may have to be moved many times in the course of the test.

(4) Initial firings. Initial firings are done to establish the initial divergence of any debris; this information is then used to modify the witness screen layout to best determine the maximum range and divergence of the debris. Place a witness screen in the line of fire at a close range; five meters has been found to be practicable for small caliber ammunition and ten meters for larger calibers. Do not cut a passage hole in the screen if the projectile is non explosive, rather fire directly through it. This will reveal any debris that may be closely following the line of fire. If the projectile is explosive, cut a passage hole in the screen aligned with the weapon bore. A hole diameter of about ten times the projectile diameter will suffice. All firings of explosive ammunition must be done with personnel suitably protected.

Fire a small number of rounds, three suggested, and examine the screen after each shot. Look for embedded debris, perforations, smudges, and any other markings on the screen. Recover any embedded debris. Measure the location of the marks relative to the line of fire.

(5) Debris distribution. Position witness screens at locations suggested by the results of the initial firings. If the initial distribution was symmetrical, witness screens need to be placed only on one side of the line of fire. The screens should initially be placed at about twice the distance as for the initial firings. Again fire a sample of rounds, scrutinize the screens, and measure the location of the marks relative to the line of fire. Repeat the process until the maximum range and dispersion is attained.

(6) It will not be possible to determine the distribution to a high degree of precision. Terminate the test if debris no longer makes any impression in the screens or the range becomes too far to be practicable. If the results are critical it will be necessary to use radar tracking along the line indicated by the witness screens.

(7) Ammunition temperature. The test is normally fired at range ambient temperatures. If firing with ammunition conditioned to extreme temperatures is required, first establish the debris pattern using ambient temperature ammunition. Then fire the temperature conditioned ammunition and observe for any changes in the debris distribution. If the actual extreme temperatures are not specified, use -46 °C (-50 °F) and 52 °C (125 °F).

c. Data Required.

(1) Identification of ammunition and support weapon.

(2) Meteorological conditions of wind and air temperature.

(3) Ammunition temperature.

(4) Description of witness screen material and size.

(5) Location of witness screens.

(6) Location of marks relative to the line of fire and weapon position.

(7) Description and photographs of any recovered debris.

(8) Results of radar tracking, if appropriate.

4.4 Terminal Ballistics.

These tests relate to the interaction of the projectile with its target. Many types of projectiles, such as armor piercing, have requirements for performance against specified targets. Other projectiles, such as for target practice, may not have any specifications for terminal performance against targets, but their terminal ballistics are important for determining range safety considerations. Targets may be intentional, such as enemy personnel, or they may be incidental, such as impact with the ground or intervening brush.

4.4.1 Fragmentation Lethality.

a. Background. The effectiveness of explosive projectiles is largely determined by the damage caused by fragmentation. The effectiveness calculations are based on detailed data concerning the fragments, their distribution, and their ballistics.

b. Test Method.

(1) The test method is detailed in ITOP 4-2-813[13], Static Testing of High-Explosive Munitions for Obtaining Fragment Spatial Distribution. The information presented below is intended to supplement the ITOP and to provide procedures specifically for Recoilless rifle ammunition. Consultation with individuals experienced in this testing should be done as early in the planning process as possible.

(2) The test munition is detonated inside a fragmentation arena which is built and instrumented in accordance with the ITOP. The relatively small size of Recoilless rifle projectiles often requires modification of the size and design of the test arena.

(3) The test munition must be modified so that it can be remotely detonated. Ideally, the modification should be designed prior to the manufacture of the projectile as it is difficult to modify fuzes after they are assembled. The modification should change the fragmentation characteristics as little as possible. The original explosive content and geometry should be preserved and any added detonators or lead charges must be as small as practicable. All the projectile components (body, fuse, nose cap, fins, etc.) should remain in their original condition and locations.

(4) Care must be taken if the projectiles must be modified after production. Most Recoilless rifle fuzes are crimped or glued to the projectile body; they must be cut from the projectile so that they can be modified. The original configuration of the fuze should be preserved and reattached to the projectile body. The procedure for such a modification must be coordinated as early as possible with safety authorities, personnel involved in the actual modification, and personnel experienced in the conduct of the test.

(5) Some Recoilless rifle explosive projectiles function only by impact after being fired (the projectiles contain energetics designed to function on a high velocity impact but still meet safe handling and transportation requirements). The ITOP procedure must be modified to permit firing the projectile into a target within the test arena. Given the generally limited fragmentation of such projectiles, the ITOP arena test may not be appropriate and a test procedure specific to the test item may have to be devised. The target (impact plate) may block the path of projected fragments so its size and material must be carefully considered. Also, the projectile orientation at impact must be recorded for proper polar zone alignment.

(6) The data from the arena is collected, reduced, and analyzed in accordance with ITOP 4-2-813. Terminal effectiveness is conducted in accordance with TOP 3-2-608[14], Terminal Effectiveness of Antipersonnel Fragmenting Projectiles. The Joint Munition Effectiveness Manual (JMEM) has publications also useful for such calculations. The manual is an unclassified document but the calculated fragmentation lethality is sometimes classified. Care must be taken to comply with the project security classification guide.

c. Data Required.

(1) Record the test set up and procedure as follows:

(a) Physical layout of the test arena including all dimensions.

(b) Type of cameras and other instrumentation.

(c) Description of the fuze modifications.

(d) Complete description of the projectile including weights of all components by material type.

(e) Fragment recovery procedure and method for determining the percent of weight recovered as a quality measure of the fragment recovery process.

(f) Procedure for determining fragment velocity and distribution.

(g) Position and orientation of the projectile within the test arena.

(h) Detailed photographs of all recovery and velocity panels after the detonation.

(i) Meteorological data including wind, temperature, air density, etc. as required.

(2) Record test data in accordance with the ITOP to include:

(a) Fragment velocities for each individual zone.

(b) Mass of each recovered fragment per zone (or number per mass group).

(c) Fragment shape factors.

4.4.2 Projectile Lethality.

a. Background. Lethality is a measure of the ability to cause death. For Recoilless rifle ammunition, lethality refers to projectiles that kill through the effects of kinetic energy. Other mechanisms, such as chemical or incendiary effects, are not considered.

b. Method. Measuring lethality is a highly specialized field requiring unique test techniques, such as firing into gelatin blocks, and expert data analysis. The expertise for lethality testing resides in the Army Research Laboratory, Survivability/Lethality Analysis Directorate (SLAD). The SLAD can conduct, analyze, and report lethality tests of Recoilless rifle ammunition.

Early coordination with the SLAD is critical; both to schedule the test and to determine what test assets will be required. The DTC test officer may have to arrange a supply of the necessary test ammunition. Since test results are specific to the weapon as well as ammunition, the test officer may need to coordinate supply of the proper weapon; this is particularly important if the support weapons are produced with different barrel lengths or muzzle attachments.

c. Data Required. The SLAD will record the necessary test data.

4.4.3 Armor Penetration.

a. Background.

(1) Recoilless rifle ammunition may be designed to penetrate armor through a variety of projectile designs but the most common is the shaped charge warheads. Some projectiles are dual purpose (HEDP), having a warhead with both a shaped charge and a fragmenting capability. This TOP does not address tests for Explosively Formed Penetrator or High Explosive Plastic (sometimes referred to as “squash head”) warheads as these are not currently used by Recoilless rifle ammunition.

(2) These procedures are for testing the penetration abilities of a projectile; they are not designed to test the degree of protection given by a specific target (such as an armored vehicle or body armor).

(3) The test methods are based on ITOP 2-2-713[15], Ballistic Testing of Armor, and on STANAG 4164[16], Test Procedures for Armour Perforation Tests of Anti-Armour Ammunition. The contents of these documents are not copied into this TOP due to the volume of information; the documents must be studied to fill in the details of the procedures noted in the test methods below.

b. Test Method.

(1) Definitions. The following definitions are applicable to the test methods in this TOP:

(a) Angle of Obliquity – The angle between the trajectory of the projectile and an imaginary line perpendicular to the target surface at the point of impact of the projectile.

(b) Complete Perforation – The target is considered to have been perforated when light can be seen through one or more holes in a witness plate placed 150 mm (6 inches) behind and parallel to the back of the target (Complete perforation of the witness plate is required to demonstrate adequate residual energy for terminal effect). The witness plate for calibers up to and including 40 mm is aluminum; alloy 2024 T3, 0.45 mm to 0.55 mm thick (0.0178 to 0.022 inches, US standard 0.020 inch plate meets this definition). The witness plate for calibers above 40 mm is mild steel 1.5 mm to 1.7 mm thick (0.059 to 0.067 inches, US standard 16 gage ungalvanized sheet steel meets this definition).

(c) Fair Hit – A hit on the target that is one projectile diameter from any visibly disturbed area surrounding a previous hit and at least two diameters from the edge of the target or any lifting hole, support structure, etc. Other criteria, such as yaw and velocity, may also apply for specific applications.

(d) Mil – An angle equal to 0.0562 of a degree (17.78 mils = 1 degree). Review requirements documents carefully, some use the term “mil” for milliradian (an angle equal to 0.0573 degrees).

(e) R_{50} – The range at which a 50% probability of complete perforation can be expected. If firing tables are available the range can be converted to striking velocity.

(f) Semi-Infinite Target – A target of such a thickness that will ensure that the projectile will not produce any disturbance, such as deformation or discoloration, on the rear surface of the plate.

(g) V_{50} – The striking velocity at which a 50% probability of complete perforation can be expected. If firing tables are available the striking velocity can be converted to range.

(h) Yaw – Any angular displacement between the projectile axis and the warhead velocity vector, irrespective of the plane of the deviation.

(i) θ_{50} - The angle of obliquity at which a 50% probability of complete perforation can be expected.

(2) Target characterization. The properties of each target must be recorded. In all cases note the armor material, specification, and manufacture’s batch number (where applicable).

(a) For plate targets, such as aluminum and RHA (Rolled Homogeneous Armor), measure and record the actual thickness and hardness. For large plates the hardness and thickness should be measured in a grid pattern, a spacing of 300mm is usually appropriate.

(b) Brittle targets, such as ceramic and glass, require special provisions for target mounting. For these materials a detailed description of the mounting is required along with identification of the target material itself. See ITOP 2-2-713, paragraph 4.2, for details of the mounting procedure.

(3) Single criterion tests. Many Recoilless rifle ammunition specifications and requirement documents give a single criterion for armor penetration capability. The criterion is usually in the form of a percentage of hits that must perforate a given plate target at a given obliquity and range. The test is done by firing under the required conditions until the specified number of fair hits is attained. The witness plate is then examined to determine the number of complete perforations. Consult with the evaluator and customer to assure a mutual understanding of the required angle of obliquity; some specifications assume that the obliquity is measured from the line of sight between the weapon and the target rather than from the trajectory. Conduct the test in accordance with the agreed upon obliquity conditions. Record the muzzle velocity of each round fired.

(4) R_{50} test procedure. This procedure requires that the distance between the weapon and target be varied between each shot. While either the target or weapon can be moved between shots, it is usually much more practicable to move the weapon. If available, use a standard armed vehicle and its fire control system. The weapon may also be mounted in a test fixture placed on the back of a truck; in this case the weapon will have to be manually aimed using suitable instruments (boresight, weapon sights, etc.).

(a) The R_{50} has advantages over other methods in that, since it is “real range”, it eliminates questions of projectile yaw influences, accuracy of range tables, effects of assembly/disassembly of ammunition, etc. Its primary disadvantage is that it requires range facilities to accommodate long range firings; also, the target size needed to assure a good probability of a fair hit may become uneconomically large (or even impossible).

(b) There are two methods commonly used to determine the shot-to-shot change in range to the target; each has its own method for data reduction and data presentation. The two methods are detailed in annexes A and B of STANAG 4164 (use range as the variable rather than obliquity) and are summarized below.

(c) Langlie method. This method gives a good estimate of R_{50} and also the standard deviation of the R_{50}; it is relatively insensitive to the initial estimate of the R_{50} point. Fire the first shot at a range midway between the best estimates of the range at which there is an assurance of complete penetration and the range where a complete penetration is highly unlikely. Following shots are done at ranges in accordance with the procedures in the STANAG. The STANAG recommends limiting firings to 12 fair hits; however, it is usually best to plan on 15 to 20 shots to give a better estimate of the R_{50} and its standard deviation. If at all possible, a statistician should review the test results after each shot in order to advice on the end point.

(d) Up and Down method (also known as the Bruceton method). This test strategy is best used when where the approximate value of R_{50} and its standard deviation is already known. A total of 12 fair hits is usually enough to complete the test. Fire the first round at the estimated R_{50} range. Subsequent shots are done at specific multiples of the expected standard deviation of R_{50} in accordance with annex B of STANAG 4164.

(5) V_{50} test procedure. This procedure is done with the same methods as the R_{50} procedure except that the range is held constant while the velocity is varied between shots. The advantage of the V_{50} method is that it can be done with limited range facilities at short distances and may eliminate some variables such as wind conditions. There are three serious disadvantages; 1. The yaw characteristics of a projectile must be determined so that the target can be located at the minimum point; the actual yaw at impact must be measured for each shot and should not exceed one degree. 2. Each shot requires downloading the ammunition to attain the unique velocity for that shot. 3. Downloading the ammunition changes the velocity to spin ratio of the in-flight projectile; this may be insignificant or it may be important enough to require that special gun barrels be procured to reestablish the proper ratio.

(6) θ_{50} test procedure. This procedure is done with the same methods as the R_{50} procedure except that the range is held constant while the target obliquity is varied between shots. A target fixture that facilitates changing the obliquity between each shot is required. The obliquity must be measured before each shot and after each shot at the actual strike location. The target may be oriented so that the obliquity is obtained by leaning the target away from the weapon, or by leaning it toward the weapon, or by rotating the target around its vertical axis.

(a) Target leaning away from the weapon: This orientation gives the best view of the target and the best access to the impact strike point. Ricochets and debris from projectile impacts will be ejected upward and away from target plate. However, the likelihood of ricochets can be a serious range safety consideration. Inspection of the witness plate may be difficult as it is under the target plate.

(b) Target leaning toward the weapon: This orientation will reduce ricochets since they will strike the ground under the target. The ground under the target will quickly become contaminated with debris; this can be a serious problem, particularly for explosive projectiles or those composed of material constituting a health hazard. The strike face of the target plate must be periodically inspected for damage or contamination due to the splash from ricochets and impact debris striking the ground under the target.

(c) Target rotated around its vertical axis: This orientation allows the best access to the target plate and witness plate; however, it will generate ricochets well off the line of fire. The orientation also raises the question that the projectile spin coupled with the vertical component of its velocity vector may cause the projectile to “dig in” or “walk off” the target.

(d) For the selected target orientation, establish a repeatable position on the target from which to measure the obliquity. Set the plate at the obliquity required for the first shot. The obliquity should be measured to an accuracy of ± 1 mil (this can be done with a gunner’s quadrant for a target in a laid back or laid forward orientation, geometric methods will be required if the target is rotated on its vertical axis). Fire the first shot. Measure the obliquity of the plate as near as possible to the actual projectile strike (targets are rarely perfectly flat and the obliquity will vary slightly across the surface). Before disturbing the target, remeasure the obliquity at the repeatable position. If the first and second measurements from the repeatable position differ, the orientation of the target has changed as a result of the projectile strike and the difference of the two measurements must be used to correct the obliquity measured near the point of impact.

(e) Continue firing using the selected procedure. Examine the witness plate after any shot that does not result in an obvious complete penetration or obvious non penetration. If at all possible, a statistician should review the test results after each shot in order to advice on the end point.

(7) Firing against semi-infinite targets: Firings against semi-infinite targets are done to determine the total depth of penetration, shape of the hole, and volume of the hole. This type of test is commonly done for shaped charge penetrators, but may also be required for kinetic energy penetrators. The target may be a single homogeneous plate, but the required thickness

may necessitate assembling the target with multiple layers of the specified armor. Firings are done at ranges and obliquities determined from requirements documents or from the Request for Test Services. A five round sample size should be fired under each required condition. After firing, the hole is measured by a variety of procedures such as X-ray, depth gages, and ultrasonic examination. The target may have to be sectioned to permit proper measurements to be made. ITOP 2-2-713, Appendix A gives detailed procedures for sectioning the target and making the required measurements.

(8) Temperature conditioning. Armor penetration tests are usually fired at range ambient temperatures. For critical applications (such as competitive testing) or for unusually severe range temperatures, condition the ammunition to 21 ± 2 °C (70 ± 4 °F. Fire samples of ammunition conditioned to -46 °C (-50 °F), and to 52 °C (125 °F) if there is a likelihood that extreme temperature may change the projectile’s penetration characteristics. Temperature conditioned ammunition should be fired within 30 seconds after it is removed from the conditioning environment.

c. Data Required. The data required is dependent on the specific procedure chosen. The list below gives general requirements, it is not all inclusive.

(1) Ammunition description:

(a) Type of munition (for example APDS, shaped charge).

(b) Penetrator material for KE rounds.

(c) Lot number.

(d) Warhead description, if any.

(e) Modifications made to the cartridge or projectile.

(2) Firing system:

(a) Type of weapon.

(b) Presence of muzzle devices such as brakes or flash hiders.

(c) Weapon mount description.

(d) Aiming procedures.

(e) Temperature conditioning, if any.

(3) Target data:

(a) Type of material, specification, batch number.

(b) Thickness at one or more locations.

(c) Hardness at one or more locations.

(d) Target mounting provisions.

(4) Witness plate:

(a) Material.

(b) Thickness.

(c) Distance behind target.

(5) Results of firing:

(a) Projectile velocity (±0.2%).

(b) Obliquity at impact point (±3 mils, ± 1mil desirable at high obliquities).

(c) Yaw angle (± 0.5 degrees (± 9 mils)).

(d) Hit location relative to existing hits, target edges, etc.

4.4.4 Terminal Effects.

a. Background. Recoilless rifle ammunition may be designed to produce a variety of terminal effects in addition to armor penetration and fragmentation lethality. The requirements for these effects are specific to the item under test and must be determined from requirements documents, cartridge specifications, contractual requirements, etc. Typical requirements include incendiary effects, breeching capability, and penetration of walls and bunkers; other types of terminal effects requirements may also be encountered. Test techniques are unique to each item. The test methods below for the more common terminal effects requirements are only general in nature must be tailored to each item. Unique requirements will require that a test method be devised to obtain the required data.

b. Test Method.

(1) Incendiary effects. There are two general types of incendiary tests; one is done to verify that the projectile does produce an incendiary flash and the other determines the ability of the incendiary flash to initiate a fire.

(a) Production of flash is determined by firing against a target plate and photographing the resulting flash. The camera is mounted at right angles to the line of fire slightly behind the target and far enough off the line of fire to assure that the camera is not damaged and that it has a field of view large enough to record the full size of the flash. If no other guidance is available, use a 2024T3 aluminum target, 2mm thick (0.080 inch plate may be used) at a range of 100 meters.

(b) The ability of the projectile to start a fire is determined by testing to the conditions of the cartridge specification. Each test is unique; general procedures can not be given in this TOP. The test procedures devised must be recorded in sufficient detail to assure that they are reproducible for future testing.

(2) Breaching capability. The breaching capability of Recoilless rifle ammunition is usually limited to urban architectural features such as doors and walls. Each test is unique and must be based on the specific requirements for the cartridge. Some areas that must be considered are:

(a) Reproducibility. The target material must be available in sufficient quantities to complete the entire test; ideally it should be such that identical items can be procured or produced for future tests.

(b) Definition of "breach". An exact definition of what constitutes a breech is required to conduct a breaching test. A door blown completely away from its frame is an obvious breach, but a door lock sufficiently damaged such that the door can be kicked in may also constitute a breach. A breach may also be defined by the dimensions of an opening.

(c) Safety. Recoilless rifle breaching ammunition is often fired at very short ranges, even to point blank range. Provisions must be made for remote firing and proper protection of test personnel. Witness screens may be needed to determine if fragments and splinters are blown back to the shooters position or the positions of friendly troops.

(d) Penetration of walls and bunkers. Penetration of walls and bunkers may be required, particularly for heaver caliber weapons. Unless otherwise directed, use standard targets built in accordance with ITOP 5-2-503[17], Timber, Masonry and Urban Type Target construction for Warhead Testing, 10 April 2003. The various walls, structures, and bunkers built to the TM specification are available from the MOUT Target Project Manager at the Redstone Technical Test Center Flight Test Branch, Redstone Arsenal, Alabama. Target penetration must be verified by witness screens behind the target or by suitable instrumentation such as for blast overpressure.

c. Data Required. The data required is dependent on the specific test procedure used. In all cases the data must be sufficient to address the test criteria and to assure that the test can be reproduced in the future.

4.4.5 Ricochet.

a. Background. This test describes the procedures for determining the ricochet range and pattern of direct fire projectiles. The data is used to determine range safety fans.

b. Test Method.

(1) The test methods are based on ITOP 4-2-814[18], Ricochet of Direct Fire Projectiles. The content of the ITOP is not copied into this TOP due to the volume of information; the document must be studied to fill in the details of the procedures noted in the test methods below.

(2) Procedures for ricochet testing vary greatly from test to test due to the specific requirements to be addressed. However, certain basics are common throughout:

(a) The impact media for the projectile is defined and maintained so that reproducible data can be generated.

(b) The velocity and impact angle (obliquity) of the impacting projectile is recorded.

(c) After impacting, the ricocheting projectile's velocity and exit angle (both elevation and azimuth) is determined. Ideally, the ricocheting projectile is tracked to ground impact.

(3) Impact media: There are a great many possible impact media, the most common are described below:

(a) Steel plate. A plate of Rolled Homogeneous Armor (RHA) is mounted in a holding fixture. A plate thickness of 25mm (1 inch) is sufficient for small caliber projectiles below about 25mm caliber. Thicker plate may be required for larger calibers. The plate surface must be clean and flat in order to provide consistent results.

(b) Sand. Damp sand is often used as it may cause less projectile deformation and thus longer range ricochets than does steel plate. The sand is contained in a large tray that can be tilted to obtain the desired angle of obliquity. A depth of 30cm (12 inches) will be sufficient for all but the largest projectiles. If the type of sand and moisture content is not stated in requirement documents or the RFTS, use the same No. 1 Dry as is used in the Sand and Dust test (paragraph 4.6.9). Saturate the sand with water and allow it to drain freely, this will give a density of approximately 1600 kg/cubic meter (100 pounds per cubic foot). The sand will require smoothing after each impact and the moisture content should be periodically checked.

(c) Earth. Earth is highly variable and it will be difficult to maintain test to test consistency. Locally obtained earth is sifted through wire fabric with a 6mm (0.25 by 0.25 inch) mesh size. Moisture content should be maintained at 6 to 9 percent. The earth should be compacted to about 3.5 Kg/square cm (50 psi) as determined by a calibrated penetrometer. The impact surface should be checked after each shot and be resmoothed as necessary.

(d) Ground impact. Existing ground features such as fields and roads may be used. Areas used for ground impact should be level and should be disked and smoothed to give as reproducible a surface as possible. Existing roads, concrete pads, etc. may also be used.

(e) Water. If water is used as an impact media, the impact angle must be controlled by raising the weapon above the level of the water and firing in depression. If a natural body of water is used, take care to do the test only when the water surface is calm and smooth.

(4) Firing distances. Fire at the impact media at ranges specified in requirements documents or the test plan. The range should be long enough that projectile yaw has damped out, but short enough to permit accurate placement of projectile impact. If there is no other guidance, use a range of 100 meters. Note that firing at small angles, particularly below 5 degrees, may be difficult as the presented area of the target is very small. For longer ranges, determine if the impact angle is to be measured from the line of sight or from the actual trajectory of the projectile at the target distance.

(5) Impact angle. It is not economically feasible to fire at a great many impact angles. Requirement documents or the test plan usually list the desired angles. In general, angles of 2.5, 5, 10 and 20 degrees will be found to bracket the angle at which ricochet occurs. The angles are often dictated by results; for example, if all the projectiles imbed themselves in the impact media at an angle of 10 degrees, there is no need to fire at 20 degrees.

(6) Determination of velocities and exit angles. Radar velocimeters are used to determine projectile velocities at impact and after ricochet. The relative locations of the radar and impact media must be surveyed to correct for angles from the line of fire. The outgoing elevation and azimuth of the projectile can be determined by tracking radar (preferred method) or by witness screens as described in ITOP 4-2-814. The tracking radar should be able to resolve angles to ± 0.1 degrees and velocities to 0.1% or 0.5 mps (which ever is highest). Use of witness screens will require precise measurements of the impact location and the locations of the holes in the witness screens as noted in the referenced ITOP. If at all possible, the outgoing projectile should be tracked to near ground impact, or to a predetermined low velocity cutoff.

(7) Sample size. Sample sizes are difficult to determine due to the commonly large shot-to-shot variability of results. The intent of ricochet testing is to give good confidence that the longest range ricochet has been determined for a given set of conditions. Therefore, testing should be continued even in the case of initially negative results; for example, even if the first five rounds of a series against sand imbed themselves, the test should be continued as there is no guarantee that the sixth round will not ricochet. Cutoff points for such occurrences should be determined before the start of the test. In the absence of other guidance, use a sample size of 50 shots per condition.

(8) Data reduction. Raw data is reduced to a tabular form for the test report. If desired, the data is further reduced to show the range safety implications; this reduction is done by a specific computer program available from the ATC Computer Applications Branch.

c. Data Required.

(1) Survey data for the locations of radars, impacts, witness screens, etc.

(2) Impact media and properties.

(3) Velocity, elevation, and azimuth at impact.

(4) Velocity, elevation, and azimuth after impact.

(5) Range and velocity data after impact.

4.5 Signature and Safety Effects.

Signature effects are those that characterize the use of a specific ammunition incidental to its intended performance. Some signature effects, such as smoke and muzzle flash, can reveal a shooter's position and interfere with his view of the target. Other effects, such as noise and recoil, have safety implications. In all cases, signature effects affect the utility and usefulness of ammunition.

4.5.1 Flash.

a. Background. Most Recoilless rifle ammunition creates flash when fired. The flash at the muzzle is usually the primary concern, but some weapons also emit a visible flash from the breech or from under the feed cover. Flash is undesirable because it can reveal a firing position to the enemy, interfere with the use of night vision devices, and cause the loss of night vision adaptation. The flash test is used to determine the flash characteristics of the ammunition when fired.

b. Test Method.

(1) The procedures for ammunition flash testing are virtually identical to those for flash tests of weapons as given by TOP 3-2-045[19].

(2) Flash tests are usually done as comparison-type tests in a dark environment. Test ammunition is fired in alternate trials with known standard ammunition. The results will determine if the test ammunition provides an increase or decrease in flash as compared to the standard ammunition.

(3) Disassemble, clean, lubricate with prescribed oil, and reassemble two support weapons. One weapon should be new and the other used, the latter being a weapon previously fired to near the end of its service life. For machineguns with operator replaceable barrels, use a single weapon with two barrels, one new and one near the end of its serviceable life. Record the bore and chamber measurements of the weapons in accordance with TOP 3-2-045.

(4) Fabricate a reference flash scale and mount the scale parallel to the support weapon. The scale can be of any design, such as alternating black and white squares painted on plywood, that will allow the measurement of muzzle flash (and any flash from other areas of the weapon) when illuminated by the flash produced by firing the weapon.

(5) Mount a video camera perpendicular to the muzzle of the newer support weapon at a distance that will photograph all of the flash and the reference scale. Position a second video camera behind the weapon in line with the weapon sights so as to photograph the flash as would be seen by the firer. Frame rate of the camera should take into consideration the anticipated length and duration of the flash to ensure the time that the largest flash is present is recorded. Typically a high speed camera is used to record the flash.

(6) Fire three rounds to condition the barrel, then photograph the weapon flash produced by the test ammunition under completely darkened conditions. For hand and shoulder weapons, photograph both a single shot and a ten round series fired as rapidly as possible. For machineguns, fire a three round burst and a twenty round burst. Some experimentation may be necessary to determine camera settings, camera positions, and rounds fired needed to produce a useable video image.

(7) Replace the test ammunition with the standard ammunition and repeat the firings exactly as was done for the test ammunition.

(8) Repeat the firings with the weapon that is near the end of its service life.

(9) If the ammunition under test is intended to be fired from a variety of weapons, repeat the above testing with each type of weapon.

c. Data Required.

(1) Description of test set up.

(2) Identification of the type of cameras, settings, etc.

(3) Identification of the support weapons.

(4) Chamber and bore measurements of the support weapons.

(5) Type of ammunition fired.

(6) Photos of the flash produced by the test and standard ammunition.

4.5.2 Smoke.

a. Background. The smoke cloud accumulated during weapon firing can obscure the target from the shooter. The cloud is also a signature effect that can reveal a firing position. The smoke produced by firing a weapon is highly dependent on the prevailing meteorological conditions, particularly the relative humidity and wind speed and direction. The visibility of the smoke is affected by lighting conditions and the background for the observation.

b. Test Method.

(1) The procedures for ammunition smoke testing are virtually identical to those for smoke tests of weapons as given by TOP 3-2-045.

(2) Recoilless rifle ammunition smoke tests are done as comparison-type tests in a windless environment. Test ammunition is fired in alternate trials with known standard ammunition. The smoke cloud accumulated at the gun during firing is evaluated from the standpoints of target obscuration when viewed from directly behind the gun and visibility (or signature) of the cloud from a distance beyond the muzzle. The results will determine if the test ammunition provides an increase or decrease in smoke as compared to the standard ammunition.

(3) Disassemble, clean, lubricate with prescribed oil, and reassemble one support weapon. Record the bore and chamber measurements of the weapons in accordance with TOP 3-2-045. It is usually not necessary to use both a new weapon and a weapon near the end of its life unless required by the test plan or customer Request for Test Services.

(4) To judge the size and density of the smoke cloud and the degree of target obscuration, use a checkerboard target approximately 2.4 m square with 0.3-m black and white squares placed in line with the weapon at a range of 100 m. Elevate the weapon to fire slightly above the target. Position a video camera behind the weapon in line with the weapon sights so as to photograph the target as would be seen by the firer. Place a second video camera perpendicular to the muzzle of the test weapon at a distance that will record the expected smoke cloud; the background for this camera should be of a contrasting color and contain features to show the relative size of the smoke cloud (an open field or the side of a building may be appropriate).

(5) Firings must be done in wind conditions as low as possible and at a relative humidity less than 75%.

(6) Fire three rounds to condition the barrel. For hand and shoulder weapons, photograph both a single shot and a ten round series fired as rapidly as possible. For machineguns, fire a three round burst and a twenty round burst. Some experimentation may be necessary to determine camera settings, camera positions, and rounds fired needed to produce a useable video image.

(7) Replace the test ammunition with the standard ammunition and repeat the firings exactly as was done for the test ammunition.

(8) If the ammunition under test is intended to be fired from a variety of weapons, repeat the above testing with each type of weapon.

c. Data Required.

(1) Description of test set up.

(2) Identification of the type of cameras, settings, etc.

(3) Identification of the support weapons.

(4) Chamber and bore measurements of the support weapons.

(5) Type of ammunition fired.

(6) Meteorological conditions: temperature, relative humidity, and wind speed and direction.

(7) Photos of the smoke produced by the test and standard ammunition.

4.5.3 Noise.

a. Background. Recoilless rifle ammunition typically produces a high noise level when fired. The noise level may be hazardous to the shooter and to nearby personnel. The noise is also a factor in position disclosure and communications.

b. Test Method.

(1) This test is conducted in general accordance with TOP 1-2-608[20], Sound Pressure Measurements. Additional information for instrumentation specifications and calibration is given in MIL-STD-1474D[21], Department of Defense Design Criteria Standard, Noise Limits; this document also details the analysis procedures and noise limit standards for Army materiel.

(2) Mount one support weapon so that the weapon muzzle is 1.6 m (5ft 3in) above ground level. The test stand should hold the weapon so that all parts of the stand are behind the weapon and no part of the stand is interposed between the muzzle and the microphone positions noted below.

(3) The test stand must be in a level open area with no sound reflecting surfaces within 15m (49ft) of the weapon.

(4) Place instrumentation microphones at a height of 1.6m at the locations specified by the test plan or requirements documents. At a minimum, use four microphones, one at each of the following positions:

(a) Shooter's left ear position (assuming a shoulder fired weapon and a right-handed shooter).

(b) 5 m (16.4ft) directly to the rear of the weapon.

(c) 5 m to the left and parallel to the weapon muzzle.

(d) 5 m to the left rear at 45° from the line of fire.

(5) Additional microphones may be needed at specific locations such as crewmember locations.

(6) Fire five single shots and record the sound pressure levels versus time at each of the microphones.

(7) If the ammunition under test is intended to be fired from a variety of weapons, repeat the above testing with each type of weapon.

c. Data Required.

(1) Identification of the test ammunition and support weapon.

(2) Meteorological data (temperature, humidity, barometric pressure, wind direction and speed).

(3) Peak pressure levels.

(4) A-duration (Pressure Wave Duration).

(5) B-Duration (Pressure Envelope Duration).

4.5.4 Recoil.

a. Background. Firing a Recoilless rifle weapon produces a rearward force that must be absorbed by the shooter or by the weapon mount. Excessive recoil can degrade training, injure the shooter, and damage weapon mounts.

b. Test Method.

(1) The procedures for ammunition recoil testing are identical to those for recoil tests of weapons as given by TOP 3-2-045.

(2) The recoil energy of a weapon may be measured by firing from an appropriate test fixture and calculating the results. TOP 3-2-826[22], Kinematics Tests of Small Arms, gives detailed procedures for measuring recoil using five wire and three wire suspended pendulums. The TOP also provides the calculation methods to determine the recoil in terms of momentum and kinetic energy. Other facilities, such as a weapon cradle mounted on linear bearings, may also be used to measure recoil.

(3) Disassemble, clean, lubricate with prescribed oil, and reassemble a support weapon. The weapon should be in the lightest configuration in which it is likely to be employed. Magazine fed weapons should be tested with an empty magazine (other than the single round to be fired). Fire the weapon both with and without muzzle devices, such as flash suppressors and muzzle compensators, if the items are designed to be operator removable.

(4) Fire three trials with each weapon configuration. Calculate the recoil values in accordance with TOP 3-2-826.

c. Data Required.

(1) Specific facility used.

(2) Firing procedure.

(3) Weapon configuration and weight.

(4) Type of ammunition fired.

(5) Calculated recoil energy and momentum.

4.6 Adverse Environments.

a. Background.

(1) By the very nature of its use, Recoilless rifle ammunition is exposed to, and must reliably operate in, adverse conditions. These adverse conditions consist of both natural environments (such as extreme temperature and rain) and in induced environments (such as exposure to dust from vehicular traffic and to weapon lubricants and cleaners). These adverse conditions vary by the climate of the geographic areas of intended use. The climatic conditions, as well as performance standards for operations, storage, and transit for each system, are specified in applicable requirements documents.

(2) The basic documents describing military environmental extremes are AR 70-38[23] (Research, Development, Test and Evaluation of Materiel for Extreme Climatic Conditions) and MIL-HDBK-310[24], Global Climatic Data for Developing Military Products. MIL-STD-810G (Environmental Test Methods) establishes uniform environmental test methods for determining the resistance of equipment to the effects of natural and induced environments peculiar to military operations. General DTC policy concerning climatic testing is given in DTC Memorandum 73-1, Testing Systems for Climatic Suitability and Effectiveness. Some adverse conditions test procedures, such as for mud, have been developed within ATC since there is no known Army wide procedure.

b. AR 70-38 requires that climatic tests be done, as a minimum, under the "basic" climate conditions as defined by the AR. If requirement documents require worldwide operation, the system must be able to operate in all four climatic design types. Also, AR 70-38 requires that ammunition be designed to meet safety requirements for all climatic design values despite their chance of being used or the requirement to operate in those climates. The climatic design types, extracted from AR 70-38 are shown in Table 1. The "Induced Air Temperature" should be used as the high temperature for each climatic design type since Recoilless rifle ammunition is subject to solar radiation in use as well as in storage.

Table 1. AR 70-38, Climatic Design Types

Climatic Design Type	Daily Cycle	Operational Conditions: Ambient Air Temperature, Daily Low °C	Daily Low °F	Daily High °C	Daily High °F	Solar Radiation BTU/hr, W/m^2	Ambient Relative Humidity (RH), %	Storage and Transit Conditions: Induced Air Temperature °C	Induced Air Temperature °F	Induced RH, %
Hot	Hot Dry (A-1)	32	90	49	120	0 to 355 (0 to 1120)	3 to 8	33 to 71	91 to 160	1 to 7
	Hot Humid (B-3)	31	88	41	105	0 to 343 (0 to 1080)	59 to 88	33 to 71	91 to 160	14 to 80
Basic	Constant High Humidity (B-1)	Nearly Constant 24 °C (75 °F)				Negligible	95 to 100	Nearly Constant 27 °C (80 °F)		95 to 100
	Variable High Humidity (B-2)	26	78	35	95	0 to 307 (0 to 970)	74 to 100	30 to 63	86 to 145	19 to 75
	Basic Hot (A-2)	30	86	43	110	0 to 355 (0 to 1120)	14 to 44	30 to 63	86 to 145	5 to 44
	Temperate (A-3)	28	82	39	102	0 to 335 (0 to 1060)	43 to 78	28 to 58	82 to 136	See note below
	Basic Cold (C-1)	-32	-25	-21	-5	Negligible	Tending toward saturation	-25 to -33	-13 to -28	Tending toward saturation
Cold	Cold (C-2)	-46	-50	-37	-35	Negligible	Tending toward saturation	-37 to -46	-35 to -50	Tending toward saturation
Severe Cold	Severe Cold (C-3)	-51 °C (-60 °F)				Negligible	Tending toward saturation	-51	-60	Tending toward saturation

Note: Humidity's for the A-3 storage condition vary too widely between different situations to be represented by a single set of conditions.

c. General Test Conditions.

(1) During environmental functioning tests, it may be desirable to condition the ammunition as would be done in operational conditions, including conditioning in fully loaded weapons (safety selector in the Safe position), including leaving a round in the weapon chamber for closed bolt firing designs; however, this is not normally done due to the safety hazards involved. The decision must be based on a careful review of the conditions for each specific test. For example, it may be acceptable to subject fully loaded weapons to the rain test since the weapon operator maintains a "hands on" control of the weapon at all times. Conversely, weapons subjected to unattended conditions, such as temperature conditioning, are not conditioned loaded as there is no continuous hand on control. Support weapons firing from the open-bolt position are prepared by leaving the chamber empty and the bolt in the seared position, these weapons must be subjected to the same safety review as for the closed bolt weapons. For some tests, and because of safety precautions, it may be more realistic to condition the support weapons "half loaded", i.e., with the bolt in the battery position and the chamber empty, so that a full stroke of the charging handle is required to completely load the weapon.

(2) If test results indicate a high number of first round failures, it may be necessary to manually operate the firing mechanism several times to restore proper operation of the weapon. When this action is performed, it will be so noted.

(3) When testing ammunition in weapons with multiple cyclic rates of fire, rotate the firing cycles among the various rates of fire.

(4) Specified lubricants to be used in each environmental test are determined by reference to appropriate manuals or other authority. In addition to observations of general weapon performance, also report requirements for additional lubrication and cleaning. Do not clean or relubricate support weapons unless required for completion of the test.

4.6.1 12.2 Meter Drop.

a. Background. The 12.2 meter (40 foot) drop test has been used for many years for safety testing of ammunition and fuzes. The test represents the free fall possibilities of ammunition during handling from dock to ship, or the possibility of between deck falls on shipboard. The objective of this test is to ensure that the ammunition is safe to handle and dispose of after being subjected to a 12 meter drop.

b. Test Method.

(1) ITOP 4-2-601[25], Drop Tests for Munitions, contains detailed instructions for the test procedures and a description of the test facility.

(2) The ITOP states a drop height of 12 meters (39.37 feet); however, an actual drop height of 12.2 meters (40.03 feet) must be used so as to support the many existing requirement documents and the historical data base, all of which are based on a drop height of 40 feet.

(3) The test ammunition is tested “as shipped” in its usual field shipping container. The ammunition is inspected, marked for individual identification, and its location within the container is recorded. A mixture of live and simulated ammunition may be used to fill the shipping container. Care must be taken to ensure that the live test items are placed in locations that will experience the most severe environments (the location will vary for the various drop orientations). The simulated ammunition may be inert loaded test items or mass models that replicated the configuration, weight, and center of gravity of the test items.

(4) A total of 12 containers of the test ammunition are required. Six containers will be temperature conditioned to +63 °C (145 °F) and six will be conditioned to -51 °C (-60 °F).

(5) Each group of six will be dropped at the following orientations (one drop per package, one package at each orientation):

(a) Bottom down (normal shipping orientation).

(b) End of package such that the ammunition is vertical facing nose down (if the ammunition is packaged in alternate directions, arbitrarily assign the nose down direction).

(c) End of package such that the ammunition is vertical facing base down.

(d) Edge of package such that the ammunition is facing nose down at a 45 degree angle.

(e) Edge of package such that the ammunition is facing nose up at a 45 degree angle.

(f) Side of package.

(6) Inspect the containers for evidence of detonation or burning, loose propellant, damage to the package and its contents, etc. For non-explosive ammunition it may be possible to open the packages for inspection. Explosive ammunition must be examined remotely. In all cases local safety regulations and procedures must be followed.

(7) Pallet drop. Requirement documents or the Request for Test Services may require that a complete pallet of the test ammunition be subjected to the 12.2 meter drop test. Some of the individual shipping and storage containers on the pallet may be filled with dummy cartridges or an inert substance to simulate the weight of the test ammunition. The minimum configuration is one container of test ammunition on one corner of the lowest layer and one container in the most central position of the lowest layer.

Three drops are required. One such that the cartridges are nose up, one such the cartridges are nose down, and one with the cartridges horizontal. It may be required to drop the pallet upside down and on its side to achieve the cartridge orientations. The test cartridges are treated and inspected as indicated in paragraphs (6) and (7) above.

c. Data Required.

(1) Results of inspections, including photographs, X-rays, etc.

(2) Orientation of each drop.

(3) Temperature of each drop.

(4) Description of the packaging configuration.

(5) Disposition of the ammunition and packaging.

4.6.2 Sequential Life Cycle Series (Secured Cargo Vibration, 2.1m Package Drop, Loose Cargo, 1.5m Bare Drop).

a. Background.

(1) This test procedure provides guidance for testing the ability of recoilless rifle ammunition to withstand the rigors of transportation and employment in a field environment. The tests are done sequentially to simulate that part of the ammunition life cycle that occurs after commercial transportation.

(2) These tests apply to ammunition being transported as cargo; they do not apply to ammunition installed in vehicle magazines.

b. Test Method.

(1) General. These tests are conducted sequentially in the order given. The ITOPs referenced for each procedure must be reviewed to determine the details of vibration schedules, instrumentation required, and facility requirements. The minimum number of units required for a Sequential Life Cycle Series is 120. The quantity is typically split equally at the upper and lower temperature extremes.

(2) Temperature conditioning. Unless specified otherwise in the requirement documentation, each test is done twice; once with the ammunition conditioned to -51 °C (-60 °F) and once at +71 °C (+160 °F).

(3) Ammunition marking. Each cartridge and ammunition package must be marked for unique identification before the start of the test. The marking will be used to identify the conditions to which each individual cartridge has been exposed. These conditions will include location in the package, orientation of drop, axis of vibration, and temperature.

(4) Inspections and sampling. The ammunition and packaging is inspected prior to the start of testing and between each test. The inspections will reveal any damage to the ammunition was caused by the test procedure either individually or cumulatively. Review any damage for safety implications; terminate the test if the damage would cause undue hazard in subsequent tests or firings. Remove a sample of ammunition after the 2.1 meter drop and after the loose cargo tests; inspect and fire the samples (and all the ammunition remaining after the 1.5 meter drop).

(a) Inspect each cartridge for damage such as looseness of the projectile or fuze, misalignment of the projectile in the cartridge case, scuffing, denting, and abrasions of the cartridge, any marking of the primer, and any other evidence of damage. If the ammunition is linked, inspect for cartridge alignment in the links, loose links, etc.

(b) Inspect the exterior of packages for damage such as dents and abrasions. Determine if any identification markings, such as lot numbers, have become illegible. Check latches, hinges, and carrying handles for proper operation. Inspect any interior packing material for wear or other damage. Visually inspect gaskets and seals for loss or damage. Do not replace containers and packing material unless failure to do so would cause an undue safety hazard in subsequent testing.

(5) Firing test samples. At a minimum all test samples must be fired to determine functionality in their intended weapon and to record their velocity. Fuzed ammunition must be tested for function at the no arm distance. If sample sizes permit, additional firings may be conducted to determine performance characteristics such as dispersion and fuze functioning at the all arm range. Fire the samples at range ambient temperatures unless otherwise specified in requirement or planning documents. Inspect fired cases for any defects. All firings must be done remotely due to the possibility of damage to the ammunition.

(6) Planning. Careful thought must be given to planning the test sequence. The number of containers, number of cartridges per container, sample sizes withdrawn, and number of cartridges remaining for the 1.5 meter drop must all be considered. This TOP does not specify a fixed sample size since Recoilless rifle ammunition packaging varies greatly and is specific to each test item. It is usually advantageous to build the sequence from the bottom up. Since the last test, the 1.5 meter drop, requires dropping separate samples at each of five orientations, it must start with some multiple of five items. Determine the number of items for a drop condition to determine the number required to start the 1.5 meter drop test (for example, if it is desired to drop ten cartridges at each condition a total of fifty will be required). Use this number, plus the number of samples to be withdrawn after the loose cargo test, to determine the number required to start the loose cargo test. Likewise, continue “up the chain” to determine the sample size needed for the 2.1 meter drop test and then for the initiation of the secured cargo vibration. Numbers may have to be changed to accommodate packaging considerations. Partially empty packages should not be dropped or vibrated. Using cartridge dummies or mass models to complete filling a package should be used only as a last resort as it is difficult to assure that these items truly replicate the vibrational characteristics of test ammunition.

(7) Secured cargo vibration. Conduct this test phase in accordance with ITOP 1-2-601[26], Laboratory Vibration Schedules. Use the type of package as would be shipped from depot storage. For most Recoilless rifle ammunition the package will be an overwrap containing two or more shipping and storage containers. Larger calibers may be shipped in single containers. Generally, the package is the largest size that would be manually handled by Soldiers in loading and unloading a vehicle (one or two man lift). Packages will be placed on the vibration table in their normal shipping orientation and will be secured such that they are constrained to move with motion of the table.

(a) Do the secured vibration in three phases. First do the tracked vehicle vibration schedules in accordance with Table B-3 of ITOP 1-2-601, next do the wheeled vehicle vibration in accordance with Figures B-1, B-2, and B-3, and finally do the two wheeled trailer vibration in accordance with Figures B-4, B-5, and B-6.

(b) Inspect the ammunition and packaging after each of the three phases. Do not replace or repair the packaging unless it is so damaged as to be unable to contain the ammunition or causes an unsafe condition.

(8) 2.1 meter package drop test. All the ammunition from the secured cargo vibration test is subjected to a 2.1 meter free fall drop in accordance with ITOP 4-2-602[27], Rough Handling Tests, Appendix A. The ammunition is dropped in its smallest shipping and storage container; this is usually the smallest configuration that has an individual security seal and is environmentally sealed against climatic conditions. For Recoilless rifle ammunition, the ITOP procedure is somewhat simplified in that five ammunition containers (or multiples of five) are required. Each container is dropped twice per the drop sampling in ITOP 4-2-602 and must include the following orientations:

(a) Bottom or side down

(b) Base end

(c) Nose end.

(d) Bottom base end edge (45 °).

(e) Bottom nose end edge (45 °).

The drop orientations may be modified if other orientations are determined to subject the ammunition and packaging to a critical stress (for example, the noses of fused ammunition impacting the side of a container dropped in a specific orientation).

Following the drops, the ammunition is removed from the packaging and both are inspected. Do not replace or repair the packaging unless it is so damaged as to be unable to contain the ammunition or causes an unsafe condition. After the inspections, the predetermined sample is removed for firing tests and the remaining ammunition and packing is retained for the loose cargo test.

(9) Loose cargo test. This test is done with unpackaged ammunition to simulate transportation as loose cargo. The test is done in accordance with ITOP 4-2-602[27], Rough Handling Tests, Appendix B. The ammunition, while unpackaged, should be configured to reproduce how a Soldier might transport it as loose cargo. For ammunitions, this test is either the first or second step of a sequential rough handling test series. Either packaged or unpackaged munitions may be tested. Munitions undergoing safety testing are expected to be safe for firing or, if damaged, safe for disposal.

(a) The materiel is placed on the test machine in a non-uniform manner, because part of the damage incurred during testing of an item which can roll is due to impacting with another item the number of test items should be greater than three.

(b) The test items are not tied down in any manner and are normally not separated by partitions that may prevent unrestricted contact. In the case of separate loading projectiles which are transported vertically, base down, with a loose projectile restrain system (LPRS), this system is used for the loose cargo test, as being representative of the service condition. The test machine is operated for 20 minutes at 5 Hz (1.3g) and 25mm double amplitude in the circular synchronous mode. In this mode, any point on the bed will move in a 25mm diameter circular path in a vertical plane. This test is equivalent to 240km of transport as loose cargo in tactical wheeled vehicles over rough terrain. For artillery projectiles, half of the test sample is tested for 20 minutes at 5 Hz in the horizontal orientation and other half in the vertical (base down) position Projectiles using energy absorbing lifting plugs must have the plugs with the proper torque before and after the test.

(c) Testing of materiel is conducted at temperature extremes when applicable. Half of a given test sample will be tested at the lower conditioning temperature (LCT) and the other half of the sample tested at the upper conditioning temperature (UCT). When planning to test at temperature extremes, sufficient conditioning time should be allowed prior to testing to ensure temperature stabilization. Temperature of the test item is maintained throughout testing. At the beginning of tests of explosive or unfamiliar items, testing may be halted to allow intermittent inspection of the test materiel. Testing may be conducted for 5 minutes with a 5 minute waiting

period to avoid the occurrence of kinetic heating. However, if the test is specifically a safety test, the entire 20 minutes of loose cargo exposure should be uninterrupted in order to provide an additional margin of safety. After the test cycle, the materiel is inspected visually for damage, and appropriate nondestructive inspections such as X-ray and magnetic particle inspections are performed. Then functioning tests are conducted to assess any effect of the rough handling environment on the performance of the item. These tests are conducted to address concerns for both the safety and any operational degradation problems.

(d) Following the completion of the loose cargo test, the ammunition is inspected. After the inspections, the predetermined sample is removed for firing tests and the remaining ammunition is retained for the 1.5 meter bare drop test.

(10) 1.5 meter bare drop test. This test is done with cartridges to simulate accidental dropping during handling, mounting/dismounting operations, etc. The test is done in accordance with ITOP 4-2-602, Rough Handling Tests, Appendix C. For Recoilless rifle ammunition, the ITOP procedure is somewhat simplified in that the five groups of ammunition are dropped, one round at a time, dropped twice in the following five orientations:

(a) Major axis vertical, nose down.

(b) Major axis vertical, base down.

(c) Horizontal.

(d) Major axis 45 degrees from vertical, nose down.

(e) Major axis 45 degrees from vertical, nose down.

(11) A flow chart for the Sequential Rough Handling test is shown below.

c. Data Required.

(1) Test Procedures:

(a) Temperatures.

(b) Vibration schedules.

(c) Axis of vibration.

(d) Drop heights and orientations.

(e) Packaging configurations (dimensions, weights, arraignment of cartridges, etc.).

(f) Identification of any repair or replacement of packaging.

(2) Ammunition Inspections:

(a) Photographs of visible damage.

(b) Evidence of looseness or misalignment.

(c) Condition of links and preloaded magazines.

(d) Any evidence of burning or detonation.

(3) Packaging inspections:

(a) Photographs of visible damage.

(b) Clarity of identification markings.

(c) Security and operation of latches, hinges, carrying handles, etc.

(d) Condition of internal packing material.

(e) Condition of gaskets and seals.

(4) Firing results:

(a) Identification of any weapon malfunctions.

(b) Velocities.

(c) Fuze function and non function.

(d) Cartridge case defects.

4.6.3 <u>Waterproofness</u>.

a. Background.

(1) This test is done to determine the ability of the test ammunition to function properly after submersion in water. Three separate procedures may be used: shallow submersion, observation for bubbles when a submerged cartridge is subjected to reduced air pressure, and deep water submersion.

(2) This test is appropriate for all types of Recoilless rifle ammunition. The procedures are not designed to test packaging or to test for the effects of long term underwater exposures.

b. Test Methods.

(1) Shallow submersion. This procedure is done in accordance with AECTP 300[28] (3), Method 307. The test items are conditioned to 10 °C above the water temperature. The depth of immersion is one meter (39 inches) and the ammunition is immersed for 30 minutes.

(a) The ammunition is submerged bare with no protection from packaging, magazine carriers, etc. The ammunition will be submerged linked or clipped such that it is the configuration likely to be carried by an individual Soldier.

(b) The test sample is inspected and fired immediately after being removed from the water.

(2) Vacuum and bubble test. This test procedure is most commonly used for acceptance tests, but may be required in a developmental test to demonstrate the produceability of the test item.

The details of the procedure must be extracted from the test item's requirement documents and specification. Generally, the completely bare test cartridges are submerged under water in an air tight transparent chamber. The air pressure above the water is reduced by 50 KPa (7.25 psig) and the cartridges are observed for any release of air bubbles.

(3) Deep submersion. This test is effective for determining if the test item can withstand deep submersion such as for beach operations or flooded ship magazines. Details of the procedure may be found in MIL-STD-331C[29], Test C4

(a) The test items are placed under water contained in a pressure vessel. Both the ammunition and water are temperature conditioned to 21±6 °C (70±10 °F) prior to the immersion. The air pressure inside the pressure vessel is increased to 100KPa (15 psi) (this pressure is approximately that of fresh water at a depth of 10.7 meters (35 feet)). The pressure is held for 60 minutes before the test sample is removed. The test sample is inspected and fired immediately after being removed from the water.

(b) An alternate procedure is to submerge the test ammunition into a natural body of water to the required depth. If no other guidance is available, condition the ammunition to the approximate water temperature and submerge it in a completely unpackaged condition for one hour. The test sample is inspected and fired immediately after being removed from the water.

(4) Inspection and firing. The test ammunition is inspected for any obvious signs of leakage. Larger caliber ammunition, particularly fuzed ammunition, should be weighed before and after being submerged. After the inspection, all the ammunition is fired and its velocity is recorded for comparison to ammunition that has not been submerged. Fuzed ammunition should also be fired for fuze function at the all armed range and at the no-fire range to verify that water has not impaired the operation of the fuze.

c. Data Required. The data required depends on the specific test procedure chosen. Typical data recorded is:

(1) Test procedure used.

(2) Temperature of the ammunition and water.

(3) Depth of submersion, or applied pressure.

(4) Time of submersion.

(5) Number of any bubbles released from a cartridge.

(6) Signs of leakage.

(7) Weights before and after submersion.

(8) Velocities of each round fired.

(9) Fuze function (range and target material).

4.6.4 Salt-Fog.

a. Background. This test determines the effects of a salt-fog atmosphere on ammunition performance. Recoilless rifle ammunition is exposed to high levels of salt in the atmosphere during coastal operations, marine transport, and operations near salt lakes and salt deserts. The test consists of 24-hour exposures to the salt fog environment alternated with 24-hour drying periods. The standard procedure uses two 24-hour exposures and two 24-hour drying periods for a total of 48 hours of exposure to the salt-fog and 48 hours of drying; this test duration may be tailored to correspond to requirements documents, test plans, etc. The number of rounds may be tailored for the specific type of ammunition and its service weapon, or to comply with requirements documents.

b. Test Method.

(1) Prepare test chamber and salt-water solution in accordance with MIL-STD-810G, Method 509.4.

(2) One half of the test ammunition should be placed in the chamber in a completely bare configuration. The other half should be configured as would typically be carried by an individual Soldier (linked ammunition should remain linked, rifle and pistol ammunition should be loaded into magazines).

(3) Operate the chamber for 24-hours as detailed in MIL-STD-810G, Method 509.4. After the 24-hour exposure, remove the test items, and drain any accumulated liquid from magazines. Do not wipe or clean the ammunition. Store the ammunition for 24 hours at standard ambient conditions (25 ± 10 °C (77 ± 18 °F) and 20- to 80-percent RH). Disturb the items as little as possible and do not make any adjustments during the drying period.

(4) Repeat the 24-hour salt fog exposure and 24-hour drying period.

(5) Alternate 96 hour method. Some requirement documents call for a 96 hour Salt-Fog test; this is done in accordance with MIL-STD 331C, Test C3. The test items are exposed continuously for 96 hours. The salt solution, temperature, etc. are the same as for MIL-STD 810G, but there are small differences in the post exposure drying conditions and the way the salt-fog condensate is measured. Refer to the MIL-STD 331C for details of the chamber operation.

(6) After the last drying period, visually inspect the ammunition and attempt to fire it using the procedures in TOP 3-2-045. If salt deposits or corrosion prevent satisfactory weapon functioning, rinse the ammunition with about one liter (one quart) of water and wipe dry with a clean cloth and again attempt to fire the ammunition. Record the projectile velocities and weapon cyclic rates (if the weapon is capable of automatic fire).

(7) Fuzed ammunitions should be fired in two equal samples, one at the no arm distance and one at the all arm distance.

(8) Record all malfunctions in accordance with paragraph 5 of TOP 3-2-045. Also record any difficulties in operating the support weapon with the exposed ammunition such as difficult magazine insertion/removal, excessive force required to charge the weapon, inability to operate firing selectors, etc.

(9) Inspect the fired cartridge cases for evidence of splits, primer leaks, etc. Inspect the support weapon for any adverse effects caused by firing the ammunition sample.

c. Data Required. Record the following:

(1) Records to substantiate proper exposure.

(2) Photographs of corrosion, damage, etc.

(3) Weapon malfunctions.

(4) All maintenance actions performed.

(5) Difficulties encountered in operating the weapons.

(6) Fuze function and non-function

(7) Velocities and cyclic rates.

4.6.5 Salt Water Immersion.

a. Background. This test determines the effects of salt-water immersion on exposed ammunition. Ammunition may be exposed to salt-water immersion both for deliberate operations (such as fording) and for incidental occasions such as transportation in watercraft. The test consists of a single immersion in salt water followed by firing samples over a period of 10 days; the number of immersions and test duration may be tailored to correspond to requirements documents, test plans, etc. This test is most appropriate for those munitions that are likely to be susceptible to corrosion (such as steel cartridge cases).

b. Test Method.

(1) Prepare a salt-water solution of 5-percent sodium chloride and 95-percent water by weight. The sodium chloride must not contain more than 0.1-percent sodium iodide and 0.2 percent other impurities. See MIL-STD-810G, Method 509.4, for detailed instructions on the preparation of the solution. The recommended sample size for this test is thirty rounds.

(2) Temperature condition the ammunition sample and the salt-water solution to within 10 °C of each other. One half of the test ammunition should be in a completely bare configuration. The other half should be configured as would typically be carried by an individual Soldier (linked ammunition should remain linked, rifle and pistol ammunition should be loaded into magazines). Immerse the ammunition in the salt-water solution for 1 minute. The solution must cover the test items completely.

(3) Remove the test items and immediately store them in a high humidity chamber (at least 90-percent RH) for a period of 10 days. On days 3, 5, 8, and 10, withdraw one fourth of the exposed ammunition, visually inspect each round, and attempt to fire it using the procedures in TOP 3-2-045. If salt deposits or corrosion prevent satisfactory weapon functioning, rinse the ammunition with about one liter (one quart) of water and wipe dry with a clean cloth and again attempt to fire the ammunition. Fuzed ammunitions should be fired in two equal samples, one at the no arm distance and one at the all arm distance.

(4) Record all malfunctions in accordance with paragraph 5 of TOP 3-2-045. Also record any difficulties in operating the support weapon with the exposed ammunition such as difficult magazine insertion/removal, excessive force required to charge the weapon, inability to operate firing selectors, etc.

(5) Inspect the fired cartridge cases for evidence of splits, primer leaks, etc. Inspect the support weapon for any adverse effects caused by firing the ammunition sample.

c. Data Required. Record the following:

(1) Records to substantiate proper exposure.

(2) Photographs of corrosion, damage, etc.

(3) Weapon malfunctions.

(4) All maintenance actions performed.

(5) Difficulties encountered in operating weapons.

(6) Fuze function and non-function.

4.6.6 Temperature-Humidity.

a. Background. This subtest determines the effect of high humidity on the functioning performance of ammunition. Effects can include surface reactions such as rust and corrosion of metallic components, material reactions such as swelling or softening of non-metallic cartridge cases and sabots, and deterioration of paint and identification markings. The high humidity environment can also adversely affect propellants and other energetics if the cartridge is not totally sealed.

b. Test Method.

(1) The humid test environment is detailed in MIL-STD-810G, Method 507.4. The procedure is based on the 48-hour cycle shown in Figure 1. The standard test requires five cycles for a total duration of 10 days. Requirements documents or the test plan may require a longer duration.

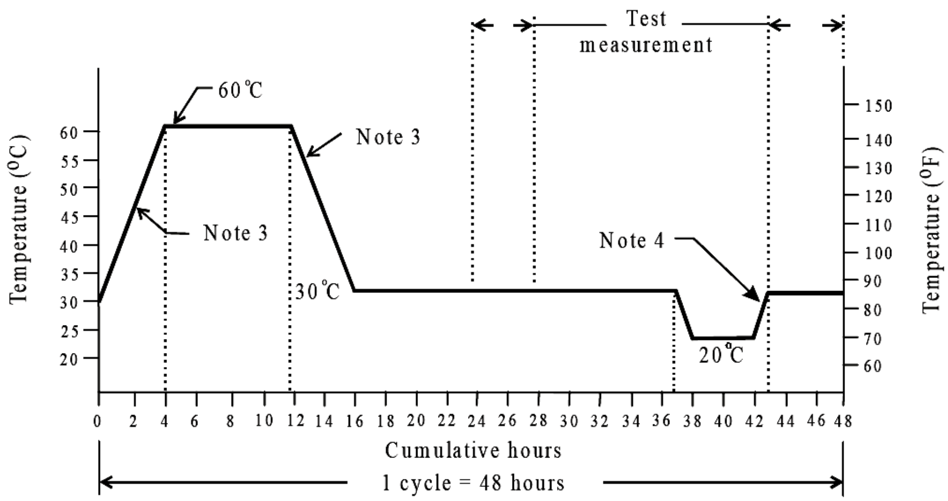

Figure 1. Humidity cycle, MIL-STD-810G, Method 507.4.

Note 1 = During temperature change, use a tolerance of not greater than 3 °C (5 °F).
Note 2 = Maintain the relative humidity at 95 ± 4 percent at all times except that during the descending temperature periods the relative humidity may drop as low as 85 percent.
Note 3 = Use a rate of temperature change between 30 and 60 °C of not less than 8 °C per hour.
Note 4 = Do not use a temperature increase in this portion of the curve that is less than 10 °C per hour.

(2) Expose ammunition sample to the temperatures and humidities indicated in Figure 1 for 10 days (five each 48-hour cycles). At the end of the 10 days of exposure, remove the ammunition and inspect it for evidence of adverse effects. Do not wipe or clean the ammunition.

(3) Fire the ammunition using the procedures in TOP 3-2-045. Record the projectile velocities and weapon cyclic rates (if the weapon is capable of automatic fire). Record all malfunctions in accordance with paragraph 5 of TOP 3-2-045. Also record any difficulties in operating the support weapon with the exposed ammunition such as excessive force required to charge the weapon, difficulty clearing stoppages, etc.

(4) If the test ammunition is fuzed, fire two samples for fuze function, one at the no arm distance and one at the all arm distance.

(5) Inspect the fired cartridge cases for evidence of splits, primer leaks, etc. Inspect the support weapon for any adverse effects caused by firing the ammunition sample.

c. Data Required. Record the following:

(1) Records to substantiate proper exposure.

(2) Photographs of corrosion, damage, etc.

(3) Weapon malfunctions.

(4) All maintenance actions performed.

(5) Difficulties encountered in operating the weapons.

(6) Fuze function and non-function.

(7) Velocities and cyclic rates.

4.6.7 Thermal Shock.

a. Background. The test munition is exposed alternately to high and low temperatures in accordance with MIL-STD 331C, Test C7, Thermal Shock. This is an accelerated environmental test that simulates the rapid temperature changes that may be encountered during transportation, air drops, and transition from storage to a tactical application. Testing is done at extreme temperatures; test items may not be required to be functional at these temperatures. However, the test items are normally required to be fully functional at their designed temperatures after exposure to the thermal shock environment.

b. Test Method.

(1) The test is conducted in accordance with MIL-STD 331C, Test C7 Thermal Shock.

(2) The ammunition is exposed unpackaged; ammunition intended to be issued in links or clips should be retained in that configuration.

(3) The test sample is placed in a temperature cabinet that is preconditioned to -54 °C (-65 °F). After a minimum of four hours the sample is removed and, in a maximum of one minute, placed in a chamber conditioned to +71 °C (+160 °F). After a minimum of four hours, the sample is removed and, in a maximum of one minute, placed back into the low temperature chamber. The cycle is repeated a total of three times (three exposures to each of the two temperatures). The storage periods may be extended to up to 64 hours to accommodate work schedules.

(4) Inspection and firing. The test ammunition is visually inspected for any obvious signs of damage. After the inspection, all the ammunition is fired and its velocity is recorded for comparison to ammunition that has not been exposed to the thermal shock test. Fuzed ammunition should also be fired for fuze function at the all armed range and no-fire range to verify that the temperature exposures have not impaired the operation of the fuze.

c. Data Required.

(1) Photographs of visible damage

(2) Clarity of identification markings

(3) Identification of any weapon malfunctions

(4) Velocities

(5) Fuze function and non function

4.6.8 Dust.

a. Background.

(1) This test determines the effects of dust on exposed ammunition. Ammunition may be exposed to airborne dust both for operations in desert environments and for incidental occasions such as transportation and mounting/dismounting from helicopters or ground vehicles.

(2) The dust test is most appropriate for those munitions that are judged likely to be affected by a dust environment. Susceptible munitions may include the following:

(a) Projectiles with external electrical contacts for fuze setting, etc.

(b) Fuzes with sensors (such as proximity fuzes) that may be degraded or obscured by dust deposits.

(c) Saboted projectiles where dust may settle in recesses (thereby changing the weight of the projectile) or where dust may affect the sabot release characteristics.

(d) Cartridge case or opturator bands of a new or unusual material.

(e) Ammunition which is issued linked or clipped.

(3) The test ammunition and weapon is exposed to the dust environment per MIL-STD 810G.

CAUTION: The dust compound used in this procedure is largely composed of silica; this material is considered hazardous under Occupational Safety and Health Administration standards. Local safety specialists should be consulted to determine proper procedures. Obtain the manufacture's Material Safety Data Sheet for additional information.

b. Test Method.

(1) This test is done using the procedures detailed in MIL-STD-810G, Dust.

(2) The compound for the blowing dust test is SIL-CO-SIL 125; this compound is 99.5-percent silicon dioxide with the particle size distribution show in the following table.

Table 2. Particle Size Distribution

Size, Microns	Less than 45	45 to 53	53 to 75	75 to 106	106 to 150
Percent, by weight	79	6	9	4.4	1.4

Supply sources are available from the manufacturer, U.S. Silica, P.O. Box 187, Berkeley Springs, WV 25411-0187, or www.u-s-silica.com.

(3) The test sample is exposed unpackaged in a completely bare condition. Ammunition that is issued linked or clipped is exposed in that configuration in order to determine if the dust has an adverse effect on the functionality of "as issued" ammunition.

(4) The ammunition is exposed to six hours of blowing dust at 23±10 °C (73±18 °F) in accordance with the air flow rates, dust concentrations, and relative humidity specified in the MIL-STD-331C procedure. After the six hours exposure, the chamber temperature is raised to 63±1.4 °C (145±2.5 °F) and the ammunition is subjected to an additional six hours exposure at that temperature.

(5) After the end of the dust exposure, visually inspect the ammunition and move it to a firing range while disturbing any dust deposits as little as possible. Fire it using the procedures in paragraph 4.1.7. The firing procedures and data recorded are somewhat dependent on the type of ammunition under test; at a minimum record the projectile velocities, dispersion, and weapon cyclic rates (if the weapon is capable of automatic fire). Fuzed ammunitions should be fired in two equal samples, one at the no arm distance and one at the all arm distance.

(6) Record all weapon malfunctions in accordance with paragraph 5 of TOP 3-2-045. Also record any difficulties in operating the support weapon with the exposed ammunition such as difficulty charging magazines, excessive force required to charge the weapon, increased maintenance requirements, etc.

(7) Inspect the fired cartridge cases for evidence of splits, primer leaks, etc. Inspect the support weapon for any adverse effects caused by firing the ammunition sample.

c. Data Required. Record the following:

(1) Records to substantiate proper exposure.

(2) Photographs of dust deposits, damage, etc.

(3) Weapon malfunctions.

(4) All maintenance actions performed.

(5) Difficulties encountered in operating the weapons.

(6) Difficulties with charging magazines, loading linked ammunition, etc.

(7) Fuze function and non-function

(8) Velocities and cyclic rates.

4.6.9 Solar Radiation.

a. Background: Recoilless rifle ammunition may be exposed to solar radiation through all phases of its use. Adverse effects result from both thermal effects and actinic effects. Thermal effects can include differential expansion resulting in loosening of projectiles and fuzes, changes in strength and elasticity of materials, and deterioration of sealants and waterproofing compounds. Actinic effects can include deterioration of composites, paints, and surface compounds. This test is most appropriate for cartridges constructed with non-metallic exterior components such as plastic cartridge cases, sabots, and coatings.

b. Method.

(1) The test environment is detailed in MIL-STD-810G, Method 505.4, Procedure 1, Cycle A1. The procedure requires three diurnal cycles (three 24-hour cycles) with a peak chamber air temperature of 49 °C (120 °F). Requirements documents or the test plan may require a different duration.

(2) One half of the test ammunition should be placed in the chamber in a completely bare configuration. The other half should be configured as would typically be carried by an individual Soldier (linked ammunition should remain linked, rifle and pistol ammunition should be loaded into magazines).

(3) Operate the chamber as required by the specified procedure. Maintain a record of chamber conditions and test item temperatures.

(4) At the end of the solar radiation exposure, remove the ammunition from the conditioning chamber and inspect each cartridge. Record any changes or damage to the ammunition. Fire the ammunition at range ambient temperature using the procedures in paragraph 4.1.7. The firing procedures and data recorded are somewhat dependent on the specific type of ammunition under test; at a minimum record the projectile velocities, dispersion, and weapon cyclic rates (if the weapon is capable of automatic fire). Fuzed munitions should be fired in two equal samples, one at the no arm distance and one at the all arm distance.

(5) Record all weapon malfunctions in accordance with paragraph 5 of TOP 3-2-045. Also record any difficulties in operating the support weapon with the exposed ammunition such as difficulty charging magazines, excessive force required to charge the weapon, increased maintenance requirements, etc.

(6) Inspect the fired cartridge cases for evidence of splits, primer leaks, etc. Inspect the support weapon for any adverse effects caused by firing the ammunition sample.

c. Data Required. Record the following:

(1) Records to substantiate proper exposure.

(2) Photographs of any visible damage or change in appearance.

(3) Weapon malfunctions.

(4) All maintenance actions performed.

(5) Difficulties encountered in operating the weapons.

(6) Fuze function and non-function

(7) Velocities and cyclic rates.

4.6.10 Extreme Temperature Storage.

a. Background. This test is for unfuzed ammunition. The test is in two phases, high temperature storage and low temperature storage. The test procedures are based on procedures contained in MIL-STD-810G. The actual storage durations may be tailored to accommodate requirement documents. Note that the extreme temperature storage test for fuzed ammunition must be based on MIL-STD-331C and those procedures are quite different.

b. Test Method.

(1) High temperature storage. The test is done in accordance with MIL-STD-810G, Method 501.4, Procedure I, for twenty-eight 24 hour cycles. The cycles vary the temperature extremes from 32 °C to 71 °C as detailed in Table 501.4-II of the MIL-STD. Ammunition normally supplied to the soldier in a clipped or linked configuration will be exposed in that condition. All packing, bandoliers, cartons, etc. will be removed before placing the test samples into the conditioning chamber.

At the end of the 28 days of exposure, remove the ammunition and inspect it for evidence of adverse effects. Fire the ammunition using the procedures in TOP 3-2-045. Record the projectile velocities and weapon cyclic rates (if the weapon is capable of automatic fire). Record all malfunctions in accordance with paragraph 5 of TOP 3-2-045. Also record any difficulties in operating the support weapon with the exposed ammunition such as excessive force required to charge the weapon, difficulty clearing stoppages, etc.

Inspect the fired cartridge cases for evidence of splits, primer leaks, etc. Inspect the support weapon for any adverse effects caused by firing the ammunition sample.

(2) Low temperature storage. The test is done in accordance with MIL-STD 810G, Method 502.4, Procedure I. The test items are maintained at -51 °C for a period of 14 days after the temperature is stabilized. Ammunition normally supplied to the soldier in a clipped or linked configuration will be exposed in that condition. All packing, bandoliers, cartons, etc. will be removed before placing the test samples into the conditioning chamber.

At the end of the 14 day exposure remove the test samples and inspect and fire them using the same procedures as for the high temperature test.

c. Data Required. Record the following:

(1) Records to substantiate proper exposure.

(2) Photographs of damage, changes in appearance etc.

(3) Weapon malfunctions.

(4) All maintenance actions performed.

(5) Difficulties encountered in operating the weapons.

(6) Velocities and cyclic rates.

4.6.11 Toxic Fumes.

a. Background.

(1) Recoilless rifle ammunition typically emits toxic fumes when fired. These fumes can degrade human performance, adversely affect short term and long-term health, and can be lethal.

(2) Common Recoilless rifle ammunition may produce ammonia (NH_3), carbon dioxide (CO_2), carbon monoxide (CO), hydrogen cyanide (HCN), nitric oxide (NO), nitrogen dioxide (NO_2), and sulfur dioxide (SO_2). Primer compounds and loss of exposed bullet lead generate lead fumes and lead residue.

b. Test Method.

(1) TOP 2-2-614[30], Toxic Hazards Test for Vehicles and Other Equipment, contains detailed instructions for the selection of instrumentation, sampling procedures, and interpretation of results.

(2) Open air toxic fumes testing of Recoilless rifle is not normally done due to the rapid dissipation of the gases and the significant effects of even very light wind.

(3) If the ammunition under test is designed to be used in armored combat vehicles (ACV), it should also be tested in accordance with paragraph 4.2 of TOP 2-2-614. Coordinate specific firing schedules with the organization responsible for testing the ACV. Recoilless weapons have a backblast and are not usually fired from inside a vehicle.

(4) Recoilless rifle toxic fumes tests are usually done as comparison-type tests in an enclosed chamber. The test ammunition is fired in alternate trials with known standard ammunition. The results will determine if the test ammunition provides an increase or decrease in toxic emissions as compared to the standard ammunition.

(5) The enclosed chamber must be sized to contain the weapon, the weapon mount, a homogenizing fan, and the sampling probes. The weapon muzzle protrudes through the wall of the chamber so that gases from the muzzle do not enter the chamber. The chamber may be bottomless so that it can be lowered over the test set up, in which case the bottom of the chamber must be sealed against the ground.

(6) The sampling probes are connected to suitable instrumentation. Typically, this is a Fourier Transform Infrared (FTIR) Spectrometer used to continuously measure concentrations of the gases emitted from the each weapon. Gases measured include ammonia (NH_3), carbon dioxide (CO_2), carbon monoxide (CO), hydrogen cyanide (HCN), nitric oxide (NO), nitrogen dioxide (NO_2), and sulfur dioxide (SO_2).

(7) Air samples are collected for lead (Pb) particulates during the firing scenarios. Air sample collection and analysis is conducted in general accordance with the National Institute for Occupational Safety and Health (NIOSH) Method 7082, which includes cellulose ester filter collection, acid digestion, and analysis by inductively coupled plasma (ICP) spectroscopy. The results are listed as total milligrams per cubic meter (mg/m^3) sampled.

(8) Due to the possibility of lead contamination in range areas, the area under the chamber and the surrounding area must be wet down to prevent air born dust from invalidating the test. Alternatively, cover the area with an impenetrable barrier such as a large plastic sheet.

(9) Remotely fire the standard ammunition to determine its toxic fumes characteristics. The usual scenario is to record fumes produced by a single shot, by a short burst of five rounds, and a long burst of 20 rounds. Adjust the round counts as needed by for the specific type of weapon and the instrumentation sensitivities and limits. Record the concentrations of toxic gases for ten minutes to permit complete mixing of the gases in the chamber.

(10) Fire three trials with the standard ammunition. Carefully purge the chamber between trials and rewet the ground if necessary. Clean the interior surfaces of the chamber by vacuuming or lightly damp mopping to remove any dust or firing residue. Remove expended cartridge cases, ammunition containers, etc. after each firing**.**

(11) Fire the test ammunition using the same procedure as for the standard ammunition.

c. Data Required.

(1) Zero time, peak, stabilized concentrations, and times for each effluent gas measured.

(2) Lead concentration levels.

(3) Chamber dimensions.

(4) Description and photographs of the weapon mounting.

(5) Positions of sampling probes and the homogenizing fan.

(6) Chamber temperature and relative humidity.

(7) Number of rounds fired in each trial.

(8) Identification of the weapons and ammunition.

(9) Time duration of each trial and time of day when it was fired.

4.7 Fuzes and Fuzed Ammunition.

Many types of recoilless rifle ammunition are equipped with fuzes to facilitate their effectiveness. Fuzes are commonly used to initiate items such as a high explosive warhead and can also be used to create an incendiary effect. Fuzes may be entirely mechanical, may contain electrical components, or may be electronic in nature.

Recoilless rifle fuzes are an integral part of cartridges as shipped from the ammunition producer; they are not shipped separately to the using Soldier. However, tests are done on bare fuzes to assure their safety and robustness for interplant shipping before being assembled to the final cartridges.

Army fuze programs are executed by the Army Fuze Management Office (AFMO), US Army Armament Research, Development & Engineering Center, ATTN: AMSRD-AAR-AIF. Most fuze testing is done with highly specific procedures that are subject to change; the test officer must assure that up to date procedures are used. The AMFO requires numerous tests to be done in the life cycle of a fuze. This TOP is limited to those tests typically carried out by the DTC.

4.7.1 Fuze Arming Distance.

a. Background. Fuzes are tested to determine the distance at which all are armed and the distance at which none are armed. Test procedures and data analysis are statistical in nature. The results aid in determining safe separation distances and effective target engagement ranges.

b. Test Method.

(1) Several documents contain detailed procedures for fuze arming distance tests. These documents include MIL-STD-331C, Test D2; STANAG 4157[31], Test B1.3; and ITOP 4-2-806[32]. The procedures noted below are based on MIL-STD-331C with some supplementation from the other documents. The test procedure used must be coordinated with the Army Fuze Management Office if the data is intended to support fuze qualification.

(2) All the fuze explosive elements must be present and it must be assembled to its intended projectile. Firings are done from the weapon in which the ammunition is intended to be used. If the fuze is intended to be used on more than one type of weapon, firings should be done from each type unless it can be verified that muzzle velocities, spin rates, and linear and angular accelerations are the same across the weapon types.

(3) Fuze function targets are placed perpendicular to the line of fire. Targets must be of sufficient thickness to reliably initiate the fuze but not so thick as to cause deflagration if the fuze itself does not initiate the explosives. If no other guidance is given, use aluminum plate, alloy 2024-T3, and use 12.7mm (1/2 inch) thick plywood for calibers greater than 30mm. Do not use plywood lower than “C” grade, such as CD grade, as it may contain voids that would invalidate functioning results.

(4) There are many general procedures for determining the shot-to-shot target distances. These procedures are the Probit, Langlie, Weibull One Shot Transformed Response (OSTR), Bruceton, and Neyer (Neyer requires proprietary software). Each procedure has advantages and disadvantages; however, since the OSTR procedure gives the best estimate for the extremities of the arming distance distribution (i.e. the non armed and all armed distances), it should be used unless otherwise directed.

(5) The Test Officer must pick the upper and lower limits to initiate the OSTR procedure; these are the distances that are expected to cause the all function and non function of the fuze. The distances for the first shot and following shots are determined from statistical tables and a computer program. The tables and program are given in STANAG 4157 Appendix B. A statistician or mathematician familiar with the OSTR procedure should advise on each step of the procedure.

(6) Fire the test rounds from their intended weapon. If at all feasible the weapon should be equipped with its standard loading and feeding mechanisms, muzzle attachments etc. Target distances are measured from the end of the barrel proper, irrespective of muzzle devices such as flash hiders, muzzle brakes, etc. Record projectile velocities for each shot.

(7) Fuze function should be recorded by suitable instrumentation such as a video camera positioned perpendicular to the target. Visual observations are not reliable, particularly for those fuzes that may function behind the target.

(8) Fuzes that do not function on the target should be observed for function on subsequent impact with the ground or a function target well past the arming target. If subsequent functions can not be verified, a “smash plate” should be used to limit range contamination with UXO.

(9) The shot distances and functioning results are used to calculate maximum likelihood estimates of the mean and standard deviation of a normal distribution.

(10) The test is conducted at temperatures given by requirement documents. If no guidance is given, divide the sample into three equal parts and do the test at +71±3 °C (+160 ±5.4 °F), +23 ±10 °C (+73 ±18 °F), and -54 ±4 °C (-65 ±7.2 °F).

c. Data Required.

(1) Identification of the weapon from which the test is fired.

(2) Details of the target material.

(3) The distance of each shot and its corresponding functioning result.

(4) Observations of fuze function on subsequent impact.

(5) Projectile velocities for each shot.

(6) Temperature at which the test was done.

4.7.2 Fuze Graze Sensitivity.

a. Background. Graze sensitivity is the ability of the fuze to be initiated by a low angle impact with a horizontal target. The angles are usually defined as being between 80 and 90 degrees obliquity; however, lesser obliquities may be specified for high angle of fire weapons such as grenade launchers. Impact surfaces may be naturally occurring terrain such as soft earth or water, or man made surfaces such as concrete or macadam.

b. Test Method.

(1) Select each impact area to be as reproducible as possible and to be consistent across the intended area of impacts.

(a) Soil: Soil should be dry and should be worked to a smooth surface. This may require plowing followed by disking and dragging. Record the moisture content and depth of loose material.

(b) Sod, grassland, maneuvers fields, etc: Record the field condition's resistance to a cone penetrometer. Photograph the area and record a description of vegetation, surface irregularities, presence of rocks, etc.

(c) Marsh and swamp: These are highly variable. Photograph the area and provide a description of vegetation, existence of surface water, irregularities, etc.

(d) Water: Record the depth and temperature of the water. Record salt concentration if it is not fresh. Preferably fire only when the water is smooth; record wave height and spacing if the water is not smooth.

(e) Particulate material such as sand or gravel: Record the gross particulate size and the density of a sample.

(f) Concrete and macadam: Photograph the area. Record any slope or crowning of the pavement.

(2) Fire the test rounds from their intended weapon. If at all feasible the weapon should be equipped with its standard loading and feeding mechanisms, muzzle attachments etc. Record the height of the weapon muzzle above the impact area, the weapon elevation, and the expected distance to impact.

(3) Record the results of each impact. Visual observations are possible but video recording is suggested as it is not always possible to determine function visually and the recording facilitates finding each specific impact point for further inspection. Possible results include projectile ricochet, projectile function on the first or subsequent impact, and projectile embedment in the target media.

Examine each impact point and record evidence of skipping, cratering, and embedment of the projectile. Record the actual range to each projectile impact and any subsequent impacts for that projectile.

CAUTION. Projectiles that imbed without detonating, or come to rest on the surface of the media, are fully armed and must be considered to be highly dangerous UXO.

(4) Maintain the impact media for a consistent surface. Resmooth soft surfaces as needed. Move the impact aim point if hard surfaces become irregular or broken up.

(5) The test is conducted at temperatures given by requirement documents. If no guidance is given, divide the sample into three equal parts and do the test at +71 ±3 °C (+160 ±5.4 °F), +23 ±10 °C (+73±18 °F), and -54 ±4 °C (-65 ±7.2 °F).

c. Data Required.

(1) Identification of the weapon from which the test is fired.

(2) Height of muzzle above the impact media and weapon elevation

(3) Details of the impact media including photographs.

(4) The distance of impact and its corresponding functioning result.

(5) Descriptions of each impact point.

(6) Temperature at which the test was done.

4.7.3 Light Brush Impact No-Fire.

a. Background. The purpose of this test is to verify that an armed fuze will not function upon unintended impact with lightweight material. The material may be of natural origin such as brush and foliage; it may also be blowing man made debris such as paper or cardboard. Fuze function on such material has safety implications because the safe separation distance between personnel and the exploding projectile is often greater than the minimum no-armed distance. There are also operational implications if the fuze sensitivity limits the tactical use of the munition, such as in heavily foliated areas.

b. Test Method. There are two general methods of testing for brush impact no-fire – firing against sheet material and firing against an array of wooden dowels. Firings can also be done against specific materials, such as camouflage netting, if needed.

(1) Fire the test rounds from their intended weapon. If at all feasible the weapon should be equipped with its standard loading and feeding mechanisms, muzzle attachments etc.

(2) Sheet material. The ITOP 4-2-806, Arming Distance and Impact Sensitivity of Fuzes, recommends 3mm wood veneer as a traditional no-fire target. This material is available commercially as 1/8th inch Luan Plywood. Erect the veneer target at a distance that assures that the test fuzes will be armed. Erect a second target (function target) of sufficient thickness to assure that an armed fuze will function. Erect the second target a distance behind the veneer target to assure an unobstructed view of the veneer and to assure that functions do not damage the veneer; a minimum of ten meters is recommended.

Fuze function should be recorded by suitable instrumentation such as a video camera positioned perpendicular to the target. Note if any projectiles function on the veneer, if so note if the function is on the veneer or at a distance behind the target. Note the function of the projectiles on the second target.

(3) Wood dowel targets. Details of construction the wood dowel target are given in MIL-STD-331C, test D6. Wooden dowels with a diameter of 8mm (5/16 inch) are mounted center-to-center 47mm (1 7/8 inch) apart to form a flat panel array. Three such panels are placed against each other, front to back; each panel is staggered 15.7mm (5/8 inches) from the one in front of it. Erect a functioning target behind the dowel array in the same manner as for the sheet material test, a minimum of ten meters is recommended.

Fuze function should be recorded by suitable instrumentation such as a video camera positioned perpendicular to the target. Note if any projectiles function on the dowels; if so note if the function is on, or in. the dowel array or at a distance behind the target. Note the function of the projectiles on the second target.

This wooden dowel test is most appropriate for projectiles of 40mm or greater as smaller caliber projectiles may pass through the array without impacting the most sensitive area of the fuze.

(4) The test is conducted at temperatures given by requirement documents. If no guidance is given, divide the sample into three equal parts and do the test at +71 ±3 °C (+160 ±5.4 °F), +23 ±10 °C (+73 ±18 °F), and -54 ±4 °C (-65 ±7.2 °F).

c. Data Required.

(1) Identification of the weapon from which the test is fired.

(2) Details of target materials and thicknesses.

(3) The distance of each target from the weapon.

(4) Observations of fuze function on the targets.

(5) Temperature at which the test was done.

4.8 Electromagnetic Environmental Effects (E3).

Recoilless rifle ammunition must be compatible with its electromagnetic environment. The ammunition must remain safe and serviceable in the electromagnetic environment and it must not adversely affect neighboring systems. Electronic fuzes are the primary area of concern; however, consideration must also be given to E3 effects on non-electronic munitions.

4.8.1 Electrostatic Discharge (ESD).

a. Background. This test simulates the exposure of ammunition to static electricity discharge during handling and transportation. ESD has the potential to initiate electroexplosive devices, electric primers, and sensitive fuze energetic material. The discharge may also damage electronic components and render the ammunition unserviceable.

b. Test Method.

(1) The test is done in accordance with STANAG 4239[33], Electrostatic Discharge. The procedures given in the STANAG are essentially identical to those in MIL-STD-331C, Test F1.2, Electrostatic Discharge. The STANAG is somewhat more applicable to assembled munitions while MIL-STD-464A concentrates on bare fuzes.

(2) Use the electrostatic discharge test parameters given in Table 1 of the STANAG. Both the personnel born and helicopter born discharge sequences are required.

(3) Minimize safety hazards by using cartridges without explosive charges and propellant. All fuze components such as electro explosive devices (EED), stab detonators, etc., should be retained in their proper configurations; booster charges, if any, may be omitted. The cartridge case must retain its primer, but should otherwise not be loaded. The fuze, projectile, and cartridge case should be assembled to their operational configuration.

(4) Selection of the test points for the test munition must be based on engineering judgment. Likely areas are:

(a) Directly to the nose of the fuze.

(b) The joint between the fuze and the body of the projectile.

(c) Exterior contacts for those fuzes utilizing them to set time or range.

(d) Any joints, slots, or other discontinuities on the surface of the fuze.

(e) Directly to the primer in the case.

(5) Function of the fuze components or primer may forcibly eject parts. The discharges should be applied remotely, and shielding should be provided to protect personnel and equipment.

(6) Following the ESD exposures, the test items should be disassembled and inspected. Note if any energetic element has functioned as a result of the discharges.

c. Data Required.

(1) Complete description of the configuration of the test items.

(2) The electrostatic parameters of each discharge.

(3) Location of the test points subjected to ESD.

(4) Results of the after test inspections.

4.8.2 High Altitude Electromagnetic Pulse (HEMP).

a. Background. This test determines a munitions’ ability to satisfy safety and reliability requirements during and after exposure to a simulated high-altitude electromagnetic pulse (HEMP) environment. The HEMP can potentially initiate EEDs and other sensitive devices and could damage or destroy electronic components.

b. Test Method.

(1) There are two procedures for doing HEMP tests. The procedure given in MIL-STD-2169 is classified and is not discussed in this TOP. For purposes of this TOP, use the procedures of NATO AOP-20[34], Test F2. It should be noted that this unclassified HEMP procedure may not be suitable for all evaluations.

(2) The AOP procedure only directly addresses fuzes; however, for purposes of this TOP, assembled cartridges are used. Minimize safety hazards by using cartridges without explosive charges and propellant. All fuze components such as electro explosive devices (EED), stab detonators, etc., should be retained in their proper configurations; booster charges, if any, may be omitted. The cartridge case must retain its primer, but should otherwise not be loaded. The fuze, projectile, and cartridge case should be assembled to their operational configuration.

(3) Apply the HEMP waveform to the test item. If the item is instrumented, a single test item is sufficient for each individual test sequence (i.e., operational mode, test configuration and orientation). If the item is not instrumented a minimum of ten items is required for each individual test. Each individual test will include exposure to at least 10 HEMP pulses.

(4) Test item parts may be forcibly ejected if fuze components or the primer function. The HEMP pulses should be applied remotely, and shielding should be provided to protect personnel and equipment.

(5) Following the HEMP exposures, the test items should be disassembled and inspected. Note if any energetic element has functioned as a result of the discharges.

(6) It is highly recommended that this test be coordinated with subject mater experts during early planning for the test project.

c. Data Required

(1) Complete description of the configuration of the test items.

(2) Description of the HEMP facility.

(3) Description of test item instrumentation, if used.

(4) Verification that the HEMP waveforms and frequency spectra were achieved.

(5) Number of pulses delivered for each item, orientation, configuration, etc.

(6) Results of post test examination of the test items.

4.8.3 Electromagnetic Radiation Operations (EMRO).

a. Background. This is a test that simulates the Electromagnetic Radiation (EMR) environment to which the test item may be exposed to during its life cycle.

b. Test Method.

(1) Follow the test procedures given in NATO AOP-20, Test F4.

(2) Assembled cartridges are used for purposes of this TOP. Minimize safety hazards by using cartridges without explosive charges and propellant. All fuze components such as electro explosive devices (EED), stab detonators, etc., should be retained in their proper configurations; booster charges, if any, may be omitted. The cartridge case must retain its primer, but should otherwise not be loaded. The fuze, projectile, and cartridge case should be assembled to their operational configuration.

(3) The test electromagnetic environment must be derived from the items specifications, relevant Military Standards, and the expected tactical environment. The minimum test environment is considered to be 200Vrms/m from 100 kHz to 40 GHz.

(4) Subject the test item to the EMR environment. If the item is instrumented, a single test item is sufficient for each individual test sequence (i.e., operational mode, test configuration and orientation). If the item is not instrumented a minimum of ten items is suggested for each individual test.

(5) Following the EMR exposures, the test items should be disassembled and inspected. Note if any energetic element has functioned as a result of the discharges.

(6) It is highly recommended that this test be coordinated with subject mater experts during early planning for the test project.

c. Data Required

(1) Complete description of the configuration of the test items.

(2) Description of the EMR facility.

(3) Description of test item instrumentation, if used.

(4) Verification that the EMR field strength and frequency spectra were achieved.

(5) Number of trials for each item, orientation, configuration, etc.

(6) Results of post test examination of the test items.

4.8.4 Electromagnetic Interference (EMI).

a. Background. Recoilless rifle ammunition must not cause electromagnetic interference with other systems nor should it be adversely affected by its electromagnetic environment. These tests are applicable to those munitions that emit electromagnetic energy (such as some proximity fuzes) and to those that contain electronic elements.

b. Test Method.

(1) There are a host of procedures relevant to EMI testing. The NATO document AECTP 500[35], Electrical/Electromagnetic Environmental Tests, provides a large list of generic test procedures, measurement techniques, and data requirements. Selection of tests and test conditions can be made only after review of the specific test item's characteristics and the environment in which it will be employed

(2) Projectiles in flight change their orientation; pitch, yaw and roll will vary throughout the trajectory. Therefore, measurements of emissions must be recorded across the spectrum of orientations.

(3) Many Recoilless rifle munitions are burst fired. Consideration must be given to interference between in-flight projectiles.

(4) The electromagnetic environment must be identified. In particular, shipboard use presents unique challenges to the test item.

(5) Test may have to be done on assembled cartridges as well as projectiles. Minimize safety hazards by using cartridges without explosive charges, propellant or primers. All fuze components such as electro explosive devices, stab detonators, etc., should be retained in their proper configurations; booster charges, if any, may be omitted. The fuze, projectile, and cartridge case should be assembled to their operational configuration. Bare projectiles should be provided with a means to activate their emitting devices and must be instrumented to determine susceptibility to the EMI.

(6) It is highly recommended that this test be coordinated with subject mater experts during early planning for the test project.

c. Data Required. The data required will depend on the specifics of each test. The data must be sufficient to permit evaluation of the test items susceptibility and its effect on neighboring systems.

4.8.5 Hazards of Electromagnetic Radiation to Ordnance (HERO).

a. Background. This test assesses the susceptibility of the test item to inadvertent activation or degraded performance as a result of exposure to specified electromagnetic environments (EME).

This test is most appropriate to Recoilless rifle ammunition that contains electronic components or electrically initiated energetics, including electric primers. The EME requirements for shipboard use are different than those for Army rotorcraft. The requirements for unrestricted use (i.e. loading and unloading with exposed cartridges) are different than those for restricted use (shipment and storage). The restricted use test is sensitive to the design of the ammunition packaging; multiple tests may be needed if likely packaging configurations vary in their shielding characteristics.

b. Test Method.

(1) This test is done in accordance with MIL-STD-464A[36], Electromagnetic Environmental Effects, Requirements for Systems, paragraph 5.8.3. Table 3A gives frequencies and field intensities for shipboard applications; use Table 1E for Army rotorcraft operations. Table A4 gives the minimum test frequencies for each frequency range.

(2) For tests for unrestricted use, expose the ammunition as it is likely to be used; a sample should be exposed as single rounds, but samples of linked or clipped cartridges should also be exposed if that is a normal configuration. Minimize safety hazards by using cartridges without explosive charges and propellant. All fuze components such as electro explosive devices (EED), stab detonators, etc., should be retained in their proper configurations; booster charges, if any, may be omitted. The cartridge case must retain its primer, but should otherwise not be loaded. The fuze, projectile, and cartridge case should be assembled to their operational configuration.

(3) Test item parts may be forcibly ejected if fuze components or the primer function. The EME should be applied remotely, and shielding should be provided to protect personnel and equipment.

(4) The test items should be disassembled and inspected following the EME exposures. Note if any energetic element has functioned as a result of the discharges.

(5) It is highly recommended that this test be coordinated with subject mater experts during early planning for the test project.

c. Data Required.

(1) Complete description of the configuration of the test items.

(2) Description of the EME facility and equipment.

(3) Description of test item instrumentation, if used.

(4) Verification that the frequencies and field strengths were achieved.

(5) Results of post test examination of the test items.

4.8.6 Near-Strike Lightning (NSL).

a. Background. This test determines a munitions' ability to satisfy safety and reliability requirements during and after exposure to a simulated near-by lightning strike. The resulting electric currents and electromagnetic fields can potentially initiate EEDs and other sensitive devices and could damage or destroy electronic components.

b. Test Method.

(1) This test is done in accordance with TOP 1-2-511[37], Intersystem Electromagnetic Compatibility Requirements System Requirements, Appendix C. Use Table C-2, Electromagnetic Fields from Nearby Lightning, to set the levels for the magnetic and electric fields. The test item will be subjected to three discharges from the lighting simulator.

(2) The TOP procedure only directly addresses EEDs; however, for purposes of this TOP, assembled cartridges are used. Minimize safety hazards by using cartridges without explosive charges and propellant. All fuze components such as electro explosive devices, stab detonators, etc., should be retained in their proper configurations; booster charges, if any, may be omitted. The cartridge case must retain its primer, but should otherwise not be loaded. The fuze, projectile, and cartridge case should be assembled to their operational configuration.

(3) Test item parts may be forcibly ejected if fuze components or the primer function. The lighting simulator discharges should be applied remotely, and shielding should be provided to protect personnel and equipment.

(4) Following the exposures, the test items should be disassembled and inspected. Note if any energetic element has functioned as a result of the discharges.

(5) It is highly recommended that this test be coordinated with subject matter experts during early planning for the test project.

(6) The US Army White Sands Missile Range maintains a lightning simulation capability.

c. Data Required

(1) Complete description of the configuration of the test items.

(2) Description of the lightning simulation facility.

(3) Description of test item instrumentation, if used.

(4) Verification that the required field strengths were achieved.

(5) Number of discharges delivered to each item, orientation, configuration, etc.

(6) Results of post test examination of the test items.

4.9 Insensitive Munitions and Hazard Classification Tests.

Insensitive munitions tests and hazard classification tests are closely related and overlapping. However, the purposes of the two groups of tests are different.

Insensitive munitions are defined by STANAG 4439[38] as “Munitions which reliably fulfill their performance, readiness and operational requirements on demand, but which minimize the probability of inadvertent initiation and severity of subsequent collateral damage to weapon platforms, logistic systems and personnel when subjected to unplanned stimuli.” The governing document for insensitive munitions testing is MIL-STD-2105C[39], Hazard Assessment Tests for Non-Nuclear Munitions. This document contains a description of the required tests, most of which are detailed in NATO STANAGs specific to each test.

Hazard Classification tests are governed by Joint Technical Bulletin TB 700-2[40], Department of Defense Ammunition and Explosives Hazard Classification Procedures. The tests are designed to classify ammunition and explosives in accordance with Department of Transportation regulations, NATO guidelines, and United Nations recommendations. The hazard classification documents risk levels for the shipment and storage of munitions.

The test officer must determine which document a given test is intended to address. For example, both documents detail a bullet impact test with very similar bullets; however the required bullet impact velocities are different.

This TOP identifies Insensitive Munitions tests and Hazard Classification tests commonly performed by DTC. It does not address laboratory explosive tests and certain highly specialized test that require unique facilities. The references noted for each test must be studied to assure compliance with the MIL-STD or Technical Bulletin. Any variation from the references must be resolved before a test is performed.

4.9.1 External Fire.

a. Background. This test assesses the test items reaction to being immersed in an external fire. The test procedures between the MIL-STD and Technical Bulletin are quite different. The data required are also different. Some requirements documents may refer to this test as the “Fast Cookoff” test.

b. Test Method.

(1) TB 700-2, Procedure 5-7.c, External Fire (bonfire) Test (UN Test 6(c)). The detailed procedures of the Technical Bulletin are not copied into this TOP. The critical requirements are as shown below:

(a) The test must be done with the intended ammunition packaging.

(b) The test stack must be not less than $0.15m^3$ ($5.3ft^3$) of the test packages, or a minimum of three packages, whichever is greater.

(c) The test package must be engulfed in a fire while supported as required by the TB.

(d) Specified witness screens must be used.

(e) Other than the witness screens, there must be no obstacle to projected debris.

(f) Video or camera coverage must be provided to determine the size of fire balls, flame jets, etc.

(g) Projected debris must be weighed and its distance from the test stack recorded.

(2) MIL-STD-2105C. The MIL-STD directs that the test be done in accordance with STANAG 4240[41], Liquid Fuel/External Fire, and Munition Test Procedures. The critical requirements of the STANAG are:

(a) The test is done in an enclosed hearth designed to completely engulf the test item in flame.

(b) Test should be done in a packaged configuration for those items (such as Recoilless rifle ammunition) likely to be stored and transported in packaging; there are no minimum size requirements.

(c) Thermocouples are required to verify flame temperatures and times.

(d) The nature of any reactions by the test item is recorded.

(e) The nature and distribution of residue and debris are recorded.

(3) With prior coordination, it may be possible to slightly modify the procedures of TB 700-2 to also satisfy the requirements of STANAG 4240. However, the procedures of the STANAG are not amenable to satisfying the TB due to the confinement of the required hearth.

c. Data Required.

(1) Description of the test set up.

(2) Test item packaging and orientation for each trial.

(3) Records of the temperature within the hearth or bonfire.

(4) Observations photographs of any reactions such as burning or explosions.

(5) Photographs of the post test item debris, hearth, bonfire structure, etc.

(6) The nature and distribution of any debris ejected from the test items or their packaging

4.9.2 Slow Heating (Slow Cookoff).

a. Background. The objective of this test is to assess the reaction, and time to reaction, of a munition when it is subjected to a continuously increasing temperature environment. The test procedures given in MIL-STD-2105C and TB 700-2 are very similar but not identical.

b. Test Method.

(1) TB 700-2. Use the detailed procedures of the Technical Bulletin test 5-7 i: 1.6 article slow cookoff test (UN Test 7(h)); these details are not copied into this TOP. The critical requirements are as shown below:

(a) The test facility is an expendable oven that can provides a thermal environment from 40 °C (104 °F) to 365 °C (689 °F).

(b) The test is done on two separate articles as would be packaged for transport.

(c) The temperature is increased at a linear rate of 3.3 °C (6 °F) per hour until a reaction occurs.

(d) The type of reaction and time to reaction are recorded. The distance and weights of any projected debris from the munition and packaging must also recorded.

(2) MIL-STD-2105C. The MIL-STD directs that the test be done in accordance with STANAG 4382[42], Slow Heating, and Munitions Test Procedure. Use Procedure 1 (Standard Test). The critical requirements of the STANAG are:

(a) The test facility is an expendable oven that can provide a temperature increase of 3.3 °C (6 °F) per hour.

(b) The test items are preconditioned in the chamber for 8 hours at 50 °C (122 °F).

(c) A minimum of two tests is required.

(d) Instrumentation must record the temperature at least once per minute.

(e) The type of reaction and time to reaction are recorded.

(3) With prior coordination, it may be possible to slightly modify the procedures of TB 700-2 or of STANAG 4382 so as to simultaneously satisfy the requirements of both.

c. Data Required.

(1) Description of the test set up.

(2) Test item packaging and orientation for each trial.

(3) Records of the time and temperature within the chamber.

(4) Observations and photographs of any reactions such as burning or explosions.

(5) Photographs of the post test item debris, oven structure, etc.

(6) The nature and distribution of any debris ejected from the test items or their packaging.

4.9.3 Bullet Impact.

a. Background. This test is used to assess the reaction of a munition to an impact of a three round burst of 12.7mm (0.5 in) armor piercing projectiles.

b. Test Method.

(1) TB 700-2. Use the detailed procedures of the Technical Bulletin, Test 5-8.j, 1.6 article bullet impact test (UN Test 7(j)); these details are not copied into this TOP. The critical requirements are as shown below:

(a) The attack armor piercing bullet must have a mass of 46 g (710 grains) and impact at a velocity of 856 ± 9 m/s (2800 ± 30 ft/sec).

(b) The burst is fired at a rate of 600 ± 50 shots per minute to impact within a circular target area of 50 mm (2 inch) diameter.

(c) The firing range should be 3 to 20 m (10 to 65 ft)

(d) The test is repeated for three different orientations of the test item, each selected so that the impacting rounds penetrate the most sensitive material(s).

(e) The nature of the reaction is recorded photographically or by video.

(2) MIL-STD-2105C. The MIL-STD directs that the test be done in accordance with STANAG 4241[43], Bullet Impact, and Munitions Test Procedures. Use Procedure 1 as it is designed to also assess Insensitive Munition requirements. The critical requirements of the STANAG are:

(a) The attack bullet is a caliber .50 armor piercing M2.

(b) Impact velocity is 850 ± 20 m/s (2789 ± 66 ft/sec).

(c) The bullets are fired in a three round burst at 600 ± 50 rounds per minute into a target area 5 cm (2in) in diameter.

(d) Three test item orientations are required; one aimed at the largest explosive component, one at the most shock sensitive component, and one with the booster as the target.

(e) Expected firing range is 20 to 30 meters (65 to 98 feet).

(f) The nature of any reaction and the nature and distribution of residue and debris are recorded.

(3) The M2 bullet required by the STANAG has a nominal weight of 45.88 grams (708 grains); normal bullet-to-bullet weight variations put this value within the 46 gram (710 grains) requirement of the TB. Therefore, the caliber .50 bullets are acceptable for both applications.

(4) The 600 ± 50 shots per minute required by both documents is the normal cyclic rate of the caliber .50 M2 Machinegun. The firing rate should be verified prior to the actual impact test.

(5) The bullet impact velocity span required by the TB is within the span specified by the STANAG; therefore, the velocity span of the TB (856 ± 9 m/s) will satisfy both requirements.

The nominal velocity of the M2 bullet fired from the caliber .50 M2 Machinegun is 856 m/s at 24 meters. This velocity will vary among ammunition lots and weapon barrels. This may make it difficult to obtain the required velocity while staying within the TB range limitations of 3 to 20 meters. A different weapon barrel or ammunition lot may give better results. The range may also be varied, within the limitations, to slightly change the impact velocity. A velocity decay value of 0.5 m/s per meter (0.48 f/s per foot) can be used to estimate the required change in range.

(6) Test item orientation requires engineering judgment, especially if firing at packaged ammunition. The following orientations will generally be appropriate:

(a) Transversely through the side of the cartridge case.

(b) Transversely through the side of the projectile if it is explosive in nature; if not explosive, longitudinally base to nose.

(c) Longitudinally nose to base (for both HE and inert projectiles).

(7) Trials should be done before the actual test. Set a simple paper target in place of the test item and fire a three round burst. Assure that velocities, weapon cyclic rates and bullet dispersion are within requirements. If requirements are met, the test item may be positioned in front of the paper target and aligned with the impact area as shown on the target.

c. Data Required.

(1) Description of the test set up, including gun to impact range.

(2) Test item orientation for each trial.

(3) Bullet velocities and weapon cyclic rates.

(4) Observations of any reactions such as burning or explosions.

(5) Photographs of the post test items.

(6) The nature and distribution of any debris ejected from the test items.

4.9.4 Fragment Impact.

a. Background. This test provides a method of assessing the reaction, if any, of a munition to the impact of a calibrated fragment representative of a bomb or artillery fragment. Use of STANAG 4496[44], Fragment Impact, Standard Impact Test and Alternate Procedure, is required by MIL-STD-2105C for insensitive munitions testing. TB 700-2 does not have an equivalent test.

b. Test Method.

(1) The test may be done on packaged or unpackaged test items. Unpackaged items are the reasonably worst case scenario. However, given the small size of most Recoilless rifle ammunition items, it may be extremely difficult to hit an individual cartridge. In such a case a package or array of test cartridges may be required to give reasonable assurance of a hit in a sensitive area.

(2) Two shots are required, one impacting in the center of the largest area of energetic material, and one in the most shock sensitive area. For explosive projectiles fire one shot transversely into the body of the projectile and one from nose to base. For non-explosive cartridges, fire one shot transverse to the cartridge case mid-point and one shot longitudinally from base to nose.

(3) The attack fragment is an 18.6 gram steel cylinder, 14.3 mm diameter. The standard impact test requires an impact velocity of 2530 ± 90 m/s (8300 ± 300 ft/s). An alternate procedure is identical except the required impact velocity is 1830 ± 60 m/s (6000 ± 200 ft/s).

(4) The alternate procedure should be used whenever possible; it can be performed with conventional gunpowder and sabot techniques whereas the standard impact test requires specialized facilities such as a gas gun. The standard impact test may be required if the Threat Hazard Analysis by the appropriate service review board indicates a credible threat of the higher velocity impact.

c. Data Required

(1) Description of the test set up, including gun to impact range.

(2) Test item orientation for each trial.

(3) Fragment velocities at impact.

(4) Observations of any reactions such as burning or explosions.

(5) Photographs of the post test items.

(6) The nature and distribution of any debris ejected from the test items.

4.9.5 Sympathetic Detonation.

a. Background. This test is used to assess the potential for a munition to sympathetically react to the initiation of an adjacent munition of the same type.

b. Test Method.

(1) TB 700-2 gives several procedures based on the expected hazard classifications. These procedures are detailed in paragraph 5-7.a, single package test (UN Test 6(a)); paragraph 5-7.b Stack test (UN Test 6(a)); and paragraph 5-7.k, 1.6 article propagation test (UN Test 7(k)).

(a) All the procedures have in common that one explosive cartridge in a package (the donor cartridge) is caused to detonate and the surrounding cartridges are observed for effects such as detonation or burning. The package must be the exact package that will be used for shipping and storage.

(b) The donor cartridge must be modified so that it can be remotely detonated. Explosive components of the donor cartridge must be retained in their original configuration to the extent possible. For most Recoilless rifle munitions, this may be done by replacing the fuze with an electric blasting cap. The fuze booster charge, if any, should be retained.

(c) The variations among the TB 700-2 test procedures relate to the number of packages tested, their configuration in a stack, and confinement by surrounding material. The choice of the specific procedure must be coordinated early in the test planning process.

(d) If any of the acceptor rounds detonate, the TB 700-2 must be reviewed for further tests needed to evaluate the consequence of the occurrence.

(2) The MIL-STD-2105C directs the use of STANAG 4396[45], Sympathetic Reaction, and Munitions Test Procedures.

(a) This test requires sufficient test packages to give a minimum total volume of 0.15 m^3 with a minimum of one donor and two acceptor packages. Inert items can not be used to meet the 0.15 m^3 requirement.

(b) Two tests are required, one without any external confinement of the test packages and one with external confinement. The external confinement can be the typical storage confinement or can be simulated with sandbags or sand/earth-filled containers stacked around the test stack at least one meter thick in all directions.

(3) Video recording of the chosen test is necessary to verify detonation of the donor round, subsequent reactions of the acceptor rounds and the time intervals for any such reactions.

The contents of each test package must be inspected after the test. Record effects on the acceptor cartridges such as detonation, burning, perforation, loose propellant or explosives, etc. Recover any ejected debris and record its weight and distance from the test packages.

(4) The procedures and data requirements of the Technical Bulletin and the STANAG are very similar. Prior coordination of the procedure details should allow one test to satisfy both documents.

CAUTION: It is possible that the detonation of the donor round can start a delayed reaction of acceptor rounds through such effects as smoldering, heating, ignition of tracers or self destruct elements, etc. A 30 minute waiting period is recommended before approaching the package.

c. Data Required

(1) Description of the test set up.

(2) Details of the modifications to the donor cartridge.

(3) Test item lay out and orientation within each package.

(4) Observations of any reactions such as burning or explosions.

(5) Photographs of the post test items and packaging.

(6) The nature and distribution of any debris ejected from the test items.

4.9.6 <u>Shaped Charge Jet Impact</u>.

a. Background. This test provides a method of assessing the reaction, if any, of a munition to the attack of a shaped charge jet. Use of STANAG 4526[46], Shaped Charge Jet, Munition Test Procedure, is required by MIL-STD-2105C for insensitive munition testing. There is no corresponding hazard classification test; however, the data from this test may be useful for that purpose.

b. Test Method.

(1) The STANAG requires the use of "a shape charge representing the 50mm Rockeye, or equivalent based on similar V^2d values" if the intent of the test is to qualify the munition as insensitive. A common substitute for the 50mm Rockeye is an 81mm precision shaped charge. For insensitive munition qualification the use of the 81mm shaped charge must be supported by the Threat Hazard Analysis authority.

(2) The test item must be full production standard. The STANAG is adaptable to both packaged and unpackaged items. Given the typically small size of Recoilless rifle munitions it is almost always best to do this test on a package to assure that the shaped charge jet strikes the energetic material. Preferably, the package is orientated to give the jet the longest possible path through the energetic material.

(3) The shaped charge standoff should let the jet fully develop but not be so far that the jet particulates; this distance depends on the specific shaped charge used. In some cases a sheet of conditioning armor may need to be placed between the charge and the test item to condition the jet. These details must be coordinated with the Threat Hazard Analysis authority before the test is done.

(4) Video recording of the test is necessary to document the reactions of the test items and the time history for any such reactions.

The contents of test package must be inspected after the test. Record effects on the cartridges such as detonation, burning, perforation, loose propellant or explosives, etc. Recover any ejected debris and record its weight and distance from the test packages.

CAUTION: It is possible that the shaped charge jet can start a delayed reaction in the target package through such effects as smoldering, heating, ignition of tracers or self destruct elements, etc. A 30 minute waiting period is recommended before approaching the package.

c. Data Required.

(1) Description of the test set up.

(2) Details of the shaped charge and the characteristics of the jet it produces.

(3) Test item lay out and orientation within the package.

(4) Shot line of the jet through the test item(s).

(5) Observations of any reactions such as burning or explosions.

(6) Photographs of the post test items and packaging.

(7) The nature and distribution of any debris ejected from the test items.

4.10 Supplemental Tests.

There are many possible Recoilless rifle ammunition tests that are rarely needed but should be considered in the planning process. The subjects and methods below give general guidance for some specific tests that may be encountered.

4.10.1 Fungus.

This test is done to determine if exposure to fungus will degrade the test ammunition. It is appropriate for those cartridges that have exposed organic components such as sabots or cartridge case coatings. Some electronic components are susceptible to fungus attack; therefore this test is appropriate if a cartridge contains electronics and has a potential pathway to fungus exposure. The test is not appropriate for metallic cartridges or if all the components are certified as not susceptible to fungus effects; this determination may also be made by local review of the materials comprising the cartridge. If needed, the test is done by exposing complete, bare, cartridges using the procedures given in MIL-STD-810G, Method 508.4.

At the end of the fungus exposure time period, remove the ammunition and inspect it for evidence of adverse effects. Wipe the ammunition with a clean dry cloth to remove the remaining fungus spore suspension. Fire the ammunition using the procedures in TOP 3-2-045. Record the projectile velocities and weapon cyclic rates (if the weapon is capable of automatic fire). Record all malfunctions in accordance with paragraph 5 of TOP 3-2-045. Also record any difficulties in operating the support weapon with the exposed ammunition such as excessive force required to charge the weapon, difficulty clearing stoppages, etc.

4.10.2 Altitude (40,000 feet)/Rapid Decompression.

Recoilless rifle ammunition may need to be transported in unpressurized aircraft cargo compartments. It may also be transported in pressurized compartments that may undergo rapid decompression. This test is needed only if components of the test ammunition are judged to be susceptible to changes in air pressure. These components include fluids that may boil or evaporate, seals and gaskets for internal voids, etc. General guidance for this test is given in NATO document AECPT 300, Climatic Environmental Tests, Method 312.5. Following the test exposure, remove the ammunition and inspect it for evidence of adverse effects. Fire the ammunition using the procedures in TOP 3-2-066. Record the projectile velocities and weapon cyclic rates (if the weapon is capable of automatic fire). Record all malfunctions in accordance with paragraph 5 of TOP 3-2-066. Also record any difficulties in operating the support weapon with the exposed ammunition such as excessive force required to charge the weapon, difficulty clearing stoppages, etc.

4.10.3 Rain.

This subtest determines the effects of a heavy rainfall on weapon performance using the test ammunition. It is appropriate when some characteristic of the test ammunition indicates that it may be affected by the simulated rainfall. Such characteristics include susceptibility to swelling, loss of case coatings, projectile weight gain, etc. Do the test in accordance with MIL-STD 810G. Ammunition should be removed from sealed containers and be exposed, along with the weapons, in its lowest packing configuration (i.e., bare cartridge, etc.). The weapons and ammunition are subjected to the water spray continuously throughout the test and are fired from within the simulated rain field. The shooter should be provided with a test fixture, bench, or table to facilitate loading and firing the weapons.

Record weapon performance in accordance with TOP 3-2-066. Also record the rate of rainfall, test duration, and water and ambient air temperature.

4.10.4 Parachute Delivery.

a. Recoilless Rifle ammunition may be delivered to a battlefield by parachute. There are a variety of methods of parachute delivery; each gives a characteristic ground impact velocity. ITOP 4-2-601, Drop Tests for Munitions, gives procedures, summarized below, for simulating parachute deliveries by vertical drop tests. These tests should be coordinated with the DTC Test Manager, Aviation, Missiles and Unmanned Systems Division, to assure proper configuration of the drop packages. The actual certification of the air drop package configuration is done by the US Army Yuma Proving Ground. The simulated drops may be done as an economical way to test the feasibility of dropping a particular ammunition or package design.

b. Prepare the drop package by placing the test items in their intended packaging and shipping containers and attaching them to the appropriate honeycomb or other shock absorbing system used in air delivery (a parachute is not needed). The ammunition is inspected, marked for individual identification, and its location within the drop package is recorded. A mixture of live and simulated ammunition may be used to load the package. Care must be taken to insure that the live test items are placed in locations that will experience the most severe environments. At a minimum, one test ammunition container will be placed on a bottom corner and one will be placed in the most constrained bottom location. The simulated ammunition may be inert loaded test items or mass models that replicated the configuration, weight, and center of gravity of the test items. The package is dropped in its normal orientation to impact on compact soil.

c. The package is dropped from a height of 4.3 meters (14.1 feet) for a Simulated Low Velocity Parachute Drop, from 38 meters (125 feet) for a Simulated High Velocity Parachute Drop, and from 107 meters (351 feet) for Malfunctioning Parachute Delivery System. These heights will provide the required impact velocities of 9.1m/s (29.9 f/s), 27m/s (88.6f/s) and 46m/s (151f/s), respectively. The higher drop heights may require the use of aircraft; if so, the actual drop height must be verified by suitable instrumentation.

d. After the drops, inspect the shock adsorbing material, any individual packages, and each cartridge. For the Low Velocity and High Velocity drops undamaged and minimally damaged cartridges must be fired to determine if the drop had any adverse effect on the test items. Record muzzle velocity, dispersion, weapon function, and fuze function for fuzed cartridges. For the Malfunctioning Parachute Delivery, inspect the ammunition and fire any that appears to be undamaged or minimally damaged. Severely damaged ammunition should be destroyed, but an effort should be made to determine if such ammunition is safe to handle or move.

4.10.5 Sand and Dust.

This subtest determines the effects of a sand and dust environment on weapon performance using the test ammunition. It is appropriate when some characteristic of the test ammunition, such as a new case material, indicates that it may be affected by the sand and dust exposure.
Do the test in accordance with MIL-STD 810G. Use the static test procedure for sand and dust exposure. Ammunition should be removed from sealed containers and be exposed, along with the weapons, in its lowest packing configuration (i.e., bare cartridge, etc.).

CAUTION: The sand and dust compounds used in this procedure are largely composed of silica; this material is considered hazardous under Occupational Safety and Health Administration standards. Local safety specialists should be consulted to determine proper procedures. Obtain the manufacture's Material Safety Data Sheet for additional information.

Record weapon performance in accordance with TOP 3-2-045. Also record the actual sand and dust dispensing rate, the chamber dimensions, and position of the weapons and ammunition while in the chamber.

5. DATA REQUIRED.

Specific data requirements are included in each individual test procedure in paragraph 4. For evaluated programs, the System Evaluation Plan (SEP) must be reviewed to assure that the required data will be obtained. For non-acquisition projects, review the Request for Test Services (RFTS) to determine data requirements.

Data should be presented using standard terminology and definitions. A comprehensive guide is presented in AOP 38[47], Glossary of Terms and Definitions Concerning the Safety and Suitability of Service Munitions, Explosives and Related Products. Standard definitions for weapon/ammunition interactions and malfunctions may be found in TOP 3-2-066, Recoilless Rifles.

6. DATA PRESENTATION.

Due to the multiplicity of subtests, this TOP does not include specific data forms or formats. In all cases, the test data must be presented in formats that are factual, comprehensive, and easy to understand. General guidance on presentation of data in reports is given in ATEC Publication Number 1-8, Technical Document Style Manual; use this guidance for both printed and electronic presentations.

Level 1 through 3 data is not usually published but it is retained for future use or analysis (see ATEC Pamphlet 73-4, System Test and Evaluation Procedures, Chapter 4, for data level definitions). Data levels 4 and 5 form the basis for test reports, safety release recommendations, etc.

Test results are analyzed by suitable statistical procedures for comparing samples, for obtaining point or interval estimates of a parameter, and for determining from test results whether specific requirements have been satisfied. ITOP 3-1-005, Statistics for Test Assessment, provides guidance on analyzing and presenting test results.

APPENDIX A. REFERENCES

1. TOP 3-2-066, Recoilless Rifles, 05 August 1983.

2. MIL-STD-810G, Environmental Engineering Considerations and Laboratory Tests, 31 October 2008.

3. DTC Pamphlet 73-1, Developmental Test Guide, 30 October 2006.

4. ITOP 3-1-005, Statistics for Test Assessment, 23 October 2006.

5. TOP 4-2-500, Ammunition Characteristics, 9 November 1981.

6. TOP 1-2-610, Human Factors Engineering Part I (Test Procedures), 15 May 1990.

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8. ITOP 3-2-810(1), Electrical Measurement of Weapon Chamber Pressure, 19 April 2002.

9. ITOP 4-2-829, Vertical Target Accuracy and Dispersion, 7 September 1999.

10. ITOP 3-2-601, Firing Tables and Ballistic Match Tests, 16 October 1995.

11. ITOP 4-2-801, Projectile Unbalance, 18 April 2002.

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14. TOP 3-2-608, Terminal Effectiveness of Antipersonnel Fragmenting Projectiles, 16 February 1982.

15. ITOP 2-2-713, Ballistic Testing of Armor, 20 November 2002.

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25. ITOP 4-2-601, Drop Tests for Munitions, 13 May 2004

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28. AECTP 300, Climatic Environmental Tests, January 2006.

29. MIL-STD-331C, Fuze and Fuze Components, Environmental and Performance Tests, 1 December 1989.

30. TOP 2-2-614, Toxic Hazards Tests for Vehicles and Other Equipment, 31 October 2003.

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32. ITOP 4-2-806, Arming Distance and Impact Sensitivity of Fuzes, 6 September 1999.

33. STANAG 4239, Electrostatic Discharge, Munitions Test Procedures, 13 October 1997.

34. AOP-20, Manual of Tests for the Safety Qualification of Fuzing Systems, April 2002.

35. AECTP 500, Electrical/Electromagnetic Environmental Tests, January 2006.

36. MIL-STD-464A, Electromagnetic Environmental Effects, 18 March 1997.

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38. STANAG 4439, Policy for Introduction, Assessment and Testing for Insensitive Munitions (MURAT), 18 November 1998.

39. MIL-STD-2105C, Hazard Assessment Tests for Non-Nuclear Munitions, 12 January 1994.

40. TB 700-2, Department of Defense Ammunition and Explosives Hazard Classification Procedures, 6 January 1998.

41. STANAG 4240, Liquid Fuel/External Fire, Munition Test Procedure, June 10, 2002.

42. STANAG 4382, Slow Heating, Munition Test Procedure, June 12, 2002.

43. STANAG 4241, Bullet Impact, Munition Test Procedure, June 10, 2002.

44. STANAG 4496, Fragment Impact, Munitions Test Procedure, 26 January 2004.

45. STANAG 4396, Sympathetic Reaction Munition Test Procedures, 15 April 2003.

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Forward comments, recommended changes, or any pertinent data which may be of use in improving this publication to the following address: Test Business Management Division (TEDT-TMB), US Army Developmental Test Command, 314 Longs Corner Road Aberdeen Proving Ground, MD 21005-5055. Technical information may be obtained from the preparing activity: US Army Aberdeen Test Center, 400 Colleran Road Aberdeen Proving Ground, MD 21005. Additional copies are can be requested through the following website: http://itops.dtc.army.mil/RequestForDocuments.aspx, or through the Defense Technical Information Center, 8725 John J. Kingman Rd., STE 0944, Fort Belvoir, VA 22060-6218. This document is identified by the accession number (AD No.) printed on the first page.